

0000265

DM-71-17

MANUAL

**TESTING PROCEDURES FOR
OPTICAL EQUIPMENT TEST KITS**

NOVEMBER 1971

STAT

DM-71-17

MANUAL

TESTING PROCEDURES
FOR OPTICAL EQUIPMENT TEST KITS

November 1971



Copy ___ of ___ Copies

CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
I	INTRODUCTION	I-1
II	GENERAL INSTRUCTIONS FOR THE USE OF THIS MANUAL	II-1
	A. The Test Program	II-1
	B. General Testing Guidelines	II-2
	1. Diopter Telescope	II-3
	2. Zoom Systems and Other Relay Optics	II-3
	3. Binocular Instruments	II-3
	4. Focus Adjustments	II-4
	5. Reading Resolution Bar-Targets	II-4
	6. Use and Care of Targets	II-5
	7. Use of Data Sheets	II-6
	8. Equipment Specification	II-7
	9. Illumination Meter	II-7
III	OPTICAL TESTING PROCEDURES	III-1
	FOCUS	III-1-1
	RESOLUTION	III-2-1
	DISTORTION	III-3-1
	ASTIGMATISM	III-4-1
	ALIGNMENT	III-5-1
	PARALLAX	III-6-1
	MAGNIFICATION	III-7-1
	NUMERICAL APERTURE	III-8-1
	FIELD-OF-VIEW	III-9-1
	ILLUMINATION	III-10-1
	SPECTRAL FILTER	III-11-1
	POLARIZATION	III-12-1
	INTERPUPILLARY DISTANCE	III-13-1
	EYE RELIEF	III-14-1
	WORKING DISTANCE	III-15-1
	OPTICAL PATH SEPARATION	III-16-1
	ORTHOGONALITY	III-17-1
	VIBRATION	III-18-1
	TENSION	III-19-1
	SURFACE TEMPERATURE	III-20-1
IV	DATA SHEETS	IV-1
V	GLOSSARY	V-1
VI	INDEX	VI-1

ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Rotatable Arm Test Positions	III-1-2
2	Format Locations For Resolution Measurements	III-2-6
3	Vignetting	III-5-8
4	Measurement of Instrument Numerical Aperture	III-9-2
5	Astigmatism and Orthogonality Target.	III-17-4

SECTION I INTRODUCTION

SECTION I

INTRODUCTION

The purpose of this manual is to provide optical acceptance testing capability for viewing instruments classed as microstereoscopes. This capability includes test methods that measure the characteristic optical parameters and the optical performance qualities of an instrument.

The manual format consists of six sections, each of which is important to the establishment of a technically competent and practically applicable testing program. The first two sections describe the general outline and use of this manual. This includes discussion on the important qualities of a testing program and general guidelines to follow in the application of the testing procedures and equipment described herein. These sections must not be overlooked in that they are a prerequisite for the thorough understanding of the material to follow.

The third section is the most important because it contains detailed procedures for the application of all optical tests to be performed. These procedures are discussed in 20 subsections, each of which contains one or more tests. The subsections include: (1) focus, (2) resolution, (3) distortion, (4) astigmatism, (5) alignment, (6) parallax, (7) magnification, (8) numerical aperture, (9) field-of-view, (10) illumination, (11) spectral effects, (12) polarization, (13) interpupillary distance, (14) eye relief, (15) working distance, (16) optical path separation, (17) orthogonality, (18) vibration, (19) film tension, and (20) surface temperature. The individual tests are listed on the contents page for ready reference.

The fourth section of the manual contains all of the data sheets referred to in the test procedures. These data sheets were purposely placed in a separate section as a matter of convenience.

The fifth and sixth sections, respectively, contain a glossary of terms used through the manual and an index which is cross-referenced to aid in the location of particular subject matter.

SECTION II

GENERAL INSTRUCTIONS FOR THE USE OF THIS MANUAL

SECTION II

GENERAL INSTRUCTIONS FOR THE USE OF THIS MANUAL

The general instructions will be discussed in two subsections. The first will consider the important qualities of a useful equipment evaluation program and the second will discuss the application of some guidelines necessary to the thorough understanding of the testing procedures described in Section III. It is recommended that these subsections be carefully reviewed before proceeding any further into the manual.

A. THE TFST PROGRAM

When attempting to evaluate a piece of optical equipment, the first step is to become thoroughly familiar with the instrument*. This familiarization must include a review of all manuals and instructions supplied by the manufacturer for the instrument's proper use and maintenance. In addition, the instrument should be used, at least briefly, in a simulated operational mode by the personnel required to make the evaluation.

The second step is to review all documents which are directly related to the instrument. These include: (1) The specifications required by the purchaser or sponsor, (2) the design specifications proposed by the manufacturer, and (3) the production specifications which accompany the instrument.

Following this, the tests presented in this manual should be reviewed so as to select those which will provide the most meaningful measurements in relation to the acceptance testing of required specifications. As an aid to this review, the contents page provides a listing of the individual tests discussed in this manual. In addition, the index should be utilized to locate tests for specific problem areas or tests with titles or descriptions differing from the terminology used in the manufacturer's specifications.

Equipped with this information, a complete optical testing program can be formulated which will fulfill all the requirements of an acceptance testing program. When

*Throughout this manual the underlined word, instrument, will be used to denote that piece of equipment which is to be tested and evaluated.

ever possible, this should include a test to measure each of the enumerated parameters and performance qualities specified by both the purchaser and the manufacturer. In addition, other tests which appear to be applicable should be included in the testing program.

Following the selection of the testing methods, a review of the performance procedures should be made to determine the most efficient order in which these tests should be applied. Some procedures utilize similar instrument configurations or test equipment and it would be more convenient to perform them in consecutive order. In most cases these tests are included in the same subsections and, with experience, may be performed simultaneously.

Finally, the testing program must consider the physical performance of the test procedure and the collection of meaningful data. This cannot be undertaken without the application of recognized experimental planning methods based upon sound statistical principles. It is not the intent of this manual to review statistical analysis methods; however, some consideration has been implicitly included.

All testing procedures given in this manual should be replicated a minimum of three times. In some cases, such as the measurement of resolution, it is required that the tests be performed by at least three different individuals. This requirement for repetition will prove valuable, especially when applied to tests which require some subjective interpretation.

Also, all data sheets, provided in Section IV of the manual, are based on three replications with space for entries of average values. The proper utilization of these sheets can include their direct use or they can serve as guidelines for the development of specific data gathering formats.

B. GENERAL TESTING GUIDELINES

This subsection presents explanations and descriptions relating to the equipment and procedures utilized in this manual and they are listed here to avoid unnecessary repetition throughout the manual.

1. Diopter Telescope: The diopter telescope has two major advantages which support its use in many of the optical tests. First, it standardizes the focus accommodation of the observer's eye, and second, it presents the observer with an additional 3X magnification.

It contains an internal reticle upon which the eye is focused, standardizing the focus accommodation of the eye, prior to making focus adjustments on instruments. The measurements performed in the testing procedures, which include the focusing of an instrument, are therefore more repeatable and reliable.

The lens combination provides a 3X magnification which becomes very useful in tests involving visual acuity. Also, in measurements on high-resolution systems, the additional magnification guarantees that the resolving power of the eye is not the limiting factor.

The manufacturer's instructions for the use of the diopter telescope should be carefully followed. Essentially, however, the diopter ring is usually rotated to the zero position and, using the eyepiece reference adjustment, the individual finds the most comfortable position for focusing on the internal reticle. The diopter telescope is now "calibrated" to the individual's eye and its eyepiece adjustment should not be rotated while that same individual is using it with the same eye.

2. Zoom Systems and Other Relay Optics: Most stereomicroscopes and microscopes contain elements between the objective and the eyepiece that affect the magnification and, in many cases, the specific relay lenses are selectable or otherwise adjustable. Since zoom systems fall into this category and since they currently seem to be the most prevalent, this manual is written with specific reference to their presence. However, for testing purposes, all references to zoom systems in the Optical Testing Procedures Section apply equally to other relay systems such as selectable magnification relay systems. Where selectable systems are present instead of zoom systems, the reference is to test the instrument at more than two different zoom settings, the instrument should be tested correspondingly at all available discrete relay magnifications.

3. Binocular Instruments: The class of viewing instruments, for which this manual is intended, contain two optical trains for each observer. These optical trains may be completely separated or may overlap in some lens or prism elements.

It is the intended policy of this manual that comparative tests of these optical trains be performed separately, utilizing the same eye of the observer in all cases. The only deviation from this policy will be specifically stated in the test procedures which require stereoscopic viewing.

4. Focus Adjustments: The determination of best focus is generally subjective and particularly difficult to achieve repeatably at low magnifications. Because of this, it is recommended that at least three replications be performed for all tests requiring the actual location or relative location of best focus.

Also, the diopter telescope and a suitable target are listed as equipment to be utilized in the performance of these testing procedures. The purpose of the diopter telescope was previously discussed in paragraph B. 1. above. The listing of a suitable target, however, was left intentionally vague due to the subjectiveness of this type of adjustment. A standard target format which is sensitive to focus adjustments has not yet been adopted. However, experience indicates that high-resolution bar-targets are the most convenient choice of targets for a sensitive measurement of the location of best focus. Therefore, although extreme care is required for high-resolution targets, it is recommended that they be used whenever a suitable target is required.

5. Reading Resolution Bar-Targets: Resolution values should be assigned by at least three independent observers. The median value shall be taken to be the correct value.

A bar group shall generally be considered resolved if: (a) The observer can correctly identify each of the bars and spaces, and (b) if the observer can see spaces between each of the bars extending the entire length of the bars. It should be noted that with targets consisting of more than 5 bars per group it becomes increasingly difficult to count the bars correctly. Thus, being able to correctly identify each of the bars and spaces is strictly a subjective evaluation based upon the observer's confidence in being able to correctly count the individual bars if a suitable pointer could be utilized.

In order to correctly place the resolution limit on an instrument, each observer should examine resolved bar groups in increasing spatial frequency until the first bar

group appears that cannot be considered to be resolved. The resolution of the immediately preceding group is the assigned resolution limit of the instrument. Spurious resolution readings may result if this procedure is not followed strictly.

Tangential and sagittal resolution may be evaluated on their respective patterns if both orientations are provided. Otherwise, the target may be rotated 90°. However, care should be taken that the value assigned to one direction does not affect the judgment of the observer in determining the value to the resolution limit in the other direction.

It has been assumed that the instrument resolution limit is based upon the use of a resolution target of the high-contrast variety. The above instructions, however, apply equally well when other than high-contrast targets are used. It is imperative, though, that the target contrast be recorded near all resolution figures when other than high-contrast targets are used. If no specification of target contrast is reported, it is to be assumed that the target was of high contrast.

6. Use and Care of Targets: All targets and scales utilized with an instrument should be viewed with the base or substrate in contact with the substage.

With photographic glass plates and film, this corresponds to the emulsion facing the objective. As an aid to the proper utilization of these photographic materials in the test procedures, the following methods are given for the selection of the emulsion side. The best method depends on the particular materials and the individual making the decision.

- The emulsion normally makes a film curl. If a piece of film is curled, the emulsion is probably on the concave surface.
- The emulsion frequently causes a dull finish. The base side is normally bright and reflects light specularly.
- If imagery is located near the edge of a glass plate, viewing at an angle through the edge of the plate (at a bright background) will reveal the surface containing the target. The other surface will only reflect the target.

d. Commercially available targets are usually made with all writing and numerical symbols in their proper orientation when viewed from the emulsion side. Note, however, that this is not a specific rule.

For nonphotographic targets (i.e., targets scribed on glass, vacuum deposition targets, etc.), the image side may be determined by observation.

If none of the above methods proves to be satisfactory, then determine the image side using the instrument. This can be accomplished by placing the target* on the instrument's substage and focusing it at a high magnification (approximately 50X to 100X). Then, after turning the target over, refocus the target (using the fine focus adjustment) and note the direction in which the objective traveled to obtain this focus. If the objective moved toward the target, then the image side is now in contact with the substage. If the objective moved away from the target, then the image side is now facing the objective.

The condition of all targets is basically dependent upon proper handling, cleaning, and storage. Targets should always be handled with gloves and held at their edges. Cleaning targets should consist of a light dusting with a camel's hair brush or recommendations specified by the manufacturer. Finally, all targets should be stored in separate containers to eliminate unnecessary dust and scratching. The containers should all be kept together in some area which is essentially free of rapid changes in environmental conditions, including changes in temperature, humidity, and vibration.

7. Use of Data Sheets: Data sheets are included, in Section IV, for each of the optical tests described in this manual. These sheets are intended to represent a general data collection format for the optical tests described and should be altered by the sponsor to meet any special requirements of prototype instruments.

Each data sheet must be completely filled out including the test performer's name, the date, and the instrument designation. In each case, the test variables are given as data table headings with ample space for the variable subheadings and the data. Also, space has been provided for replicate and average values for all data.

*If the target is on photographic film, it must be held flat to the substage surface through the use of a film holder, tape, or some other means.

As an example of the use of these data sheets, the order is referred to the Data Sheet for Resolution Test No. 2. In the performance of this test, the choice of optical trains, extension arms and tangential or sagittal resolution values will determine the number of data sheets required. The instrument component values will then be recorded in their appropriate spaces as zoom magnification values, eyepiece magnification values, and objective magnification values. Finally, four positions are available for data collected at each combination of the three component variables. These are intended for the three replicate resolution values and one average value as shown below.

Replicate No. 1	Replicate No. 2
Replicate No. 3	Average of Replicates

In the special case of resolution tests, it is recommended that separate sets of data sheets be used by each of the personnel selected to perform one replicate of the tests. Then, after they have performed their respective replicate and recorded the data, the results should be combined to one final set of data sheets. By following this procedure, the personnel performing the tests will not be influenced by the values recorded in the previous performance of the test.

8. Equipment Specification: All of the equipment required in Section III, Optical Testing Procedures, of this manual, has been assigned a Test Kit Component (TKC) number. This number specifies the particular piece of equipment required by the optical test to be performed and labels each piece of equipment as found in the Optical Equipment Test Kit.

9. Illumination Meter: The illumination meter described in Illumination Test No. 1 of this manual is not a highly sophisticated illumination measurement device, but is rather an inexpensive, portable device that is capable of measuring approximate illumination levels of light tables as well as serve as exposure meter for any required instrument photographs. Its proper use will require some interpretation of the meter scale and a conversion chart to relate the meter readings to any larger foot-candle meter that is utilized as a calibrated standard.

The meter has been found to be repeatable in its measurements and is very easy to use for these measurements. It requires minimal set-up time and requires very few operational instructions.

SECTION III OPTICAL TESTING PROCEDURES

It is the intended policy of this manual that comparative tests of these optical trains be performed separately, utilizing the same eye of the observer in all cases. The only deviation from this policy will be specifically stated in the test procedures which require stereoscopic viewing.

4. Focus Adjustments: The determination of best focus is generally subjective and particularly difficult to achieve repeatedly at low magnifications. Because of this, it is recommended that at least three replications be performed for all tests requiring the actual location or relative location of best focus.

Also, the diopter telescope and a suitable target are listed as equipment to be utilized in the performance of these testing procedures. The purpose of the diopter telescope was previously discussed in paragraph B. 1. above. The listing of a suitable target, however, was left intentionally vague due to the subjectiveness of this type of adjustment. A standard target format which is sensitive to focus adjustments has not yet been adopted. However, experience indicates that high-resolution bar-targets are the most convenient choice of targets for a sensitive measurement of the location of best focus. Therefore, although extreme care is required for high-resolution targets, it is recommended that they be used whenever a suitable target is required.

5. Reading Resolution Bar-Targets: Resolution values should be assigned by at least three independent observers. The median value shall be taken to be the correct value.

A bar group shall generally be considered resolved if: (a) The observer can correctly identify each of the bars and spaces, and (b) if the observer can see spaces between each of the bars extending the entire length of the bars. It should be noted that with targets consisting of more than 5 bars per group it becomes increasingly difficult to count the bars correctly. Thus, being able to correctly identify each of the bars and spaces is strictly a subjective evaluation based upon the observer's confidence in being able to correctly count the individual bars if a suitable pointer could be utilized.

In order to correctly place the resolution limit on an instrument, each observer should examine resolved bar groups in increasing spatial frequency until the first bar

group appears that cannot be considered to be resolved. The resolution of the immediately preceding group is the assigned resolution limit of the instrument. Spurious resolution readings may result if this procedure is not followed strictly.

Tangential and sagittal resolution may be evaluated on their respective patterns if both orientations are provided. Otherwise, the target may be rotated 90°. However, care should be taken that the value assigned to one direction does not affect the judgment of the observer in determining the value to the resolution limit in the other direction.

It has been assumed that the instrument resolution limit is based upon the use of a resolution target of the high-contrast variety. The above instructions, however, apply equally well when other than high-contrast targets are used. It is imperative, though, that the target contrast be recorded near all resolution figures when other than high-contrast targets are used. If no specification of target contrast is reported, it is to be assumed that the target was of high contrast.

6. Use and Care of Targets: All targets and scales utilized with an instrument should be viewed with the base or substrate in contact with the substage.

With photographic glass plates and film, this corresponds to the emulsion facing the objective. As an aid to the proper utilization of these photographic materials in the test procedures, the following methods are given for the selection of the emulsion side. The best method depends on the particular materials and the individual making the decision.

- The emulsion normally makes a film curl. If a piece of film is curled, the emulsion is probably on the concave surface.
- The emulsion frequently causes a dull finish. The base side is normally bright and reflects light specularly.
- If imagery is located near the edge of a glass plate, viewing at an angle through the edge of the plate (at a bright background) will reveal the surface containing the target. The other surface will only reflect the target.

d. Commercially available targets are usually made with all writing and numerical symbols in their proper orientation when viewed from the emulsion side. Note, however, that this is not a specific rule.

For nonphotographic targets (i.e., targets scribed on glass, vacuum deposition targets, etc.), the image side may be determined by observation.

If none of the above methods proves to be satisfactory, then determine the image side using the instrument. This can be accomplished by placing the target* on the instrument's substage and focusing it at a high magnification (approximately 50X to 100X). Then, after turning the target over, refocus the target (using the fine focus adjustment) and note the direction in which the objective traveled to obtain this focus. If the objective moved toward the target, then the image side is now in contact with the substage. If the objective moved away from the target, then the image side is now facing the objective.

The condition of all targets is basically dependent upon proper handling, cleaning, and storage. Targets should always be handled with gloves and held at their edges. Cleaning targets should consist of a light dusting with a camel's hair brush or recommendations specified by the manufacturer. Finally, all targets should be stored in separate containers to eliminate unnecessary dust and scratching. The containers should all be kept together in some area which is essentially free of rapid changes in environmental conditions, including changes in temperature, humidity, and vibration.

7. Use of Data Sheets: Data sheets are included, in Section IV, for each of the optical tests described in this manual. These sheets are intended to represent a general data collection format for the optical tests described and should be altered by the sponsor to meet any special requirements of prototype instruments.

Each data sheet must be completely filled out including the test performer's name, the date, and the instrument designation. In each case, the test variables are given as data table headings with ample space for the variable subheadings and the data. Also, space has been provided for replicate and average values for all data.

*If the target is on photographic film, it must be held flat to the substage surface through the use of a film holder, tape, or some other means.

As an example of the use of these data sheets, the reader is referred to the Data Sheet for Resolution Test No. 2. In the performance of this test, the choice of optical trains, extension arms and tangential or sagittal resolution values will determine the number of data sheets required. The instrument component values will then be recorded in their appropriate spaces as zoom magnification values, eyepiece magnification values, and objective magnification values. Finally, four positions are available for data collected at each combination of the three component variables. These are intended for the three replicate resolution values and one average value as shown below.

Replicate No. 1	Replicate No. 2
Replicate No. 3	Average of Replicates

In the special case of resolution tests, it is recommended that separate sets of data sheets be used by each of the personnel selected to perform one replicate of the tests. Then, after they have performed their respective replicate and recorded the data, the results should be combined to one final set of data sheets. By following this procedure, the personnel performing the tests will not be influenced by the values recorded in the previous performance of the test.

8. Equipment Specification: All of the equipment required in Section III, Optical Testing Procedures, of this manual, has been assigned a Test Kit Component (TKC) number. This number specifies the particular piece of equipment required by the optical test to be performed and labels each piece of equipment as found in the Optical Equipment Test Kit.

9. Illumination Meter: The illumination meter described in Illumination Test No. 1 of this manual is not a highly sophisticated illumination measurement device, but is rather an inexpensive, portable device that is capable of measuring approximate illumination levels of light tables as well as serve as an exposure meter for any required instrument photographs. Its proper use will require some interpretation of the meter scale and a conversion chart to relate the meter readings to any larger foot-candle meter that is utilized as a calibrated standard.

The meter has been found to be repeatable in its measurements and is very easy to use for these measurements. It requires minimal set-up time and requires very few operational instructions.

SECTION III
OPTICAL TESTING PROCEDURES

TEST DESIGNATION _____ FOCUS TEST NO. 1 _____

A. MEASUREMENT PERFORMED

Parfocalization of a single optical train with interchangeable or selectable objectives (exclusive of or without a zoom system).

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 1 given in Section IV.

C. PROCEDURE

Use an eyepiece furnished with the instrument (10X or the closest to this) and the highest power objective furnished with the instrument. Turn the zoom adjustment (if there is one) to its highest magnification. If rotatable arms are incorporated in the instrument, they should remain in either the 3 or 9 position (see Figure 1) throughout the test.

1. Focus, with the instrument focus control, on the glass target, through an adjusted* diopter telescope and a single optical train.
 2. Place the dial gauge in contact with a surface on the instrument that will move with the focus control.
 3. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.
 4. Replace the highest power objective with one of the lower power objectives, leaving the zoom at its highest magnification.
 5. Refocus on the glass target, using the instrument focus control and adjusted diopter telescope and the same optical train. Record the value of the dial gauge. If,
- *Adjustment and directions for the use of a diopter telescope are contained in Section II.

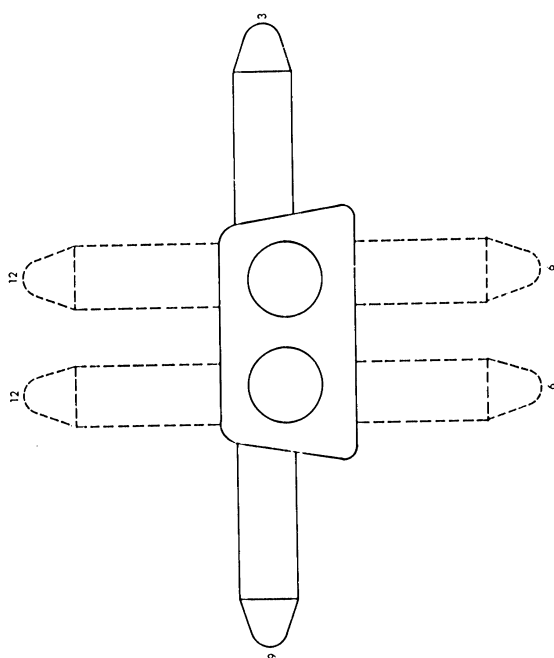


Figure 1. Retractable Arm Test Positions

In order to refocus, the objective must be moved toward the target, it shall be recorded as a positive (+) deviation. If, in order to refocus, the objective must be moved away from the target, it shall be recorded as a negative (-) deviation.

6. Repeat steps 4 and 5 for each of the remaining objectives. In each case the diopter telescope shall be used in determining best focus. It is important that the dials on the diopter telescope not be moved between readings.

7. Convert all dial gauge values to metric units where 0.001 in. = 25.4 micrometers.

Note: If the distance of travel, required by refocusing, exceeds the range of the dial indicator, the vernier calipers (TKC-19) must be utilized in this measurement. Use the surface of the light table as a reference for this distance measurement.

D. ACCURACY

The accuracy depends upon the operator and the instrument's depth of field. However, with practice, ± 0.001 in. should be obtainable at the higher magnifications.

TEST DESIGNATION FOCUS TEST NO. 2

A. MEASUREMENT PERFORMED

Parfocalization of a zoom mechanism in a single optical train.

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 2 given in Section IV.

C. PROCEDURE

Use an eyepiece furnished with the instrument (10X or the closest to this) and the highest power objective furnished with the instrument. Turn the zoom adjustment to its highest magnification. If rotatable arms are incorporated in the instrument, they should remain in either the 3 or the 9 position (see Figure 1) throughout the test.

1. Focus, with the instrument focus control, on the glass target, through an adjusted* diopter telescope and a single optical train.
2. Place the dial gauge in contact with a surface on the instrument that will move with the focus control.
3. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.
4. Select four other zoom magnification positions. Make sure that these positions cover the entire range of instrument zoom magnification possibilities.
5. Set zoom magnification to one of the positions selected in step 4.
6. Refocus on the glass target, using the instrument focus control and adjusted diopter telescope and the same optical train. Record the value of the dial gauge. If, in order to refocus, the objective must be moved toward the target, it shall be recorded

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

as a positive (+) deviation. If, in order to refocus, the objective must be moved away from the target, it shall be recorded as a negative (-) deviation.

7. Repeat steps 4 and 5 for each of the zoom magnification positions. In each case the diopter telescope shall be used in determining best focus. It is important that the dials on the diopter telescope not be moved between readings.

8. Convert all dial gauge values to metric units where 0.001 in. = 25.4 micrometers.

D. ACCURACY

The accuracy depends upon the operator and the instrument's depth of field. However, with practice, ± 0.001 in. should be obtainable at the higher magnifications.

TEST DESIGNATION FOCUS TEST NO. 3

A. MEASUREMENT PERFORMED

Relative focus or parfocalization between the left and the right optical trains in binocular instrument.

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 3 given in Section IV.

C. PROCEDURE

Select the highest power objective and zoom magnification and a pair of matched eyepieces furnished with the instrument (10X or the closest to this). If rotatable arms are incorporated in the instrument, they should remain in the 3 and the 9 positions respectively (see Figure 1) throughout the test.

1. If the instrument has an acuity adjustment in one eyepiece, focus the other optical train on the target with the instrument focus control while viewing through an adjusted* diopter telescope. If both eyepieces have acuity adjustments, turn the adjustment in the right eyepiece to approximately the middle of its travel. Then, focus through it, with the instrument focus control, on the glass target while viewing through the adjusted diopter telescope. If the instrument does not have an acuity adjustment, focus the right optical train, as above, using the diopter telescope and proceed to step 4.

2. Move the diopter telescope to the other eyepiece and, using only its acuity adjustment, focus this optical train on the target. It is important to use the same eye and diopter telescope setting for all measurements. The use of the acuity adjustment will provide correct relative focus measurements for this magnification. A "0" value should be recorded on the data sheet for this magnification.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

3. Select four other zoom magnifications on the zoom dial and change the zoom to one of these magnifications. Then, refocus the first optical train on the target, through the diopter telescope, using the instrument focus control.

4. Place the dial gauge in contact with a surface on the instrument that will move with the focus control and adjust the gauge to a dial indicator value of "0".

5. Move the diopter telescope to the other eyepiece and focus this optical train on the target using only the instrument focus control. Note the change in the indicator dial reading and the zoom magnification and record both on the data sheet. If, in order to refocus, the objective must be moved toward the target, the deviation shall be recorded as positive (+). If, in order to refocus, the objective must be moved away from the target, the deviation shall be recorded as negative (-).

6. Repeat steps 3 through 5 for each of the remaining zoom magnifications.

7. Repeat the procedures followed in steps 3 through 5 for each of the objectives supplied with the instrument and using only the highest zoom magnification available. Note that a change in focus within one optical train due to a change in either objective or zoom magnification is not to be measured in this test. This test should only reflect differences between optical trains.

8. Convert all dial gauge values to metric units where 0.001 in. = 25.4 micro-meters.

D. ACCURACY

The accuracy depends upon the operator and the instrument's depth of field. However, with practice, ± 0.001 in. should be obtainable at the higher magnifications.

TEST DESIGNATION FOCUS TEST NO. 4

A. MEASUREMENT PERFORMED

Acuity adjustment or eyepiece focus adjustment for instruments with one adjustable eyepiece.

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 4 given in Section IV.

C. PROCEDURE

Use the two lowest power eyepieces furnished with the instrument. Use the highest power objectives and turn the zoom to its maximum magnification.

1. Place adjusted* diopter telescope on the eyepiece that is not adjustable.
2. Focus, using the instrument focus control, on the glass target through the adjusted diopter telescope.
3. Place diopter telescope over the adjustable eyepiece.
4. Focus, using only the eyepiece adjustment, on the glass target through the adjusted diopter telescope.
5. Place the dial gauge in contact with the adjustable eyepiece so that it will monitor the movement of the eyepiece along the optical axis.
6. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.
7. Turn eyepiece focus adjustment to its lowest position.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

8. Record the distance traveled as the negative value of λ . This distance is the difference between the initial gauge value (step 6) and the final gauge value.

9. Turn eyepiece focus adjustment to its highest position and record this gauge value.

10. Record the difference between the final gauge value and the initial gauge value (step 6) as the positive value λ' .

11. Convert the units of the λ values to meters where 1 in. = 0.0254 meters.

12. Calculate the limits of eyepiece travel in diopters, from the position of par-focalization between the optical trains, using the following formulas:

$$D = \frac{M}{0.25 + M \lambda} - M' 0.25$$

$$D' = \frac{M}{0.25 + M \lambda'} - M' 0.25$$

where D is the positive limit of eyepiece adjustment in diopters.

D' is the negative limit of eyepiece adjustment in diopters.

M is the magnification of the eyepiece.

λ is the negative eyepiece displacement in meters.

λ' is the positive eyepiece displacement in meters.

D. ACCURACY

The accuracy depends upon the operator, the eyepiece magnification, and the dial gauge. A value of 0.1 diopter is anticipated.

TEST DESIGNATION FOCUS TEST NO. 5

A. MEASUREMENT PERFORMED

Acuity adjustment or eyepiece focus adjustment for instruments with two adjustable eyepieces.

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 5 given in Section IV.

C. PROCEDURE

Use the two lowest power eyepieces furnished with the instrument. Use the highest power objectives and turn the zoom to its maximum magnification.

1. Turn one eyepiece adjustment to its lowest position.
2. Place dial gauge in contact with this eyepiece so that it will monitor the movement of the eyepiece along the optical axis.
3. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.
4. Turn the eyepiece focus adjustment to its highest position.
5. Record the difference between the two dial gauge values as the distance λ .
6. Convert the units of λ to meters, where 1 in. = 0.0254 meter.
7. Compute the distances λ and λ' using the formulas

$$\lambda' = \frac{19 \cdot \lambda}{10 + (100 + 16 \cdot \lambda) \cdot \lambda}$$

$$\lambda = \lambda' - \lambda'$$

where λ and λ' are, respectively, the negative and positive eyepiece displacements in meters corresponding to equal positive and negative limits of eyepiece adjustment in diopters; the value M is the eyepiece magnification.

III-1-10

8. Convert the units of λ' to inches, where 1 meter = 39.37 in.

9. Subtract the value of λ' obtained in step 8 from the dial gauge value obtained in step 5.

10. Turn the eyepiece focus adjustment to the focus position corresponding to the dial gauge value calculated by step 9. This eyepiece should now be in a position corresponding to a mean focus position. The maximum allowable movement in either direction from this point is equivalent in terms of diopters.

11. Remove dial gauge and place the adjusted* diopter telescope on this eyepiece. Do not change adjustable focus position of this eyepiece throughout the remaining steps.

12. Focus, using the instrument focus control, on the glass target through the adjusted diopter telescope.

13. Place the adjusted diopter telescope on the eyepiece of the other optical train.

14. Focus, using only the focus adjustment of this eyepiece, on the glass target through the adjusted diopter telescope.

15. Place the dial gauge in contact with this adjustable eyepiece so that it will monitor the movement of the eyepiece along the optical axis.

16. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.

17. Turn this eyepiece focus adjustment to its lowest position.

18. Record the distance traveled as the negative value of λ . This distance is the difference between the initial dial value (step 16) and this dial gauge value.

19. Turn the eyepiece focus adjustment to its highest position and record the dial gauge value.

20. Record the difference between the final gauge value and the initial gauge value (step 16) as the positive value of λ .

21. Convert the units of λ and λ' to meters, where 1 in. = 0.0254 meter.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

III-1-11

22. Calculate the limits of eyepiece travel, in diopters, from the position of par-focalization between the optical trains, using the following formula:

$$D = \frac{M}{0.25 + M \lambda} - M' 0.25$$

$$D' = \frac{M}{0.25 + M \lambda'} - M' 0.25$$

where D is the positive limit of eyepiece adjustment in diopters.

D' is the negative limit of eyepiece adjustment in diopters.

M is the magnification of the eyepiece.

λ is the negative eyepiece displacement in meters.

λ' is the positive eyepiece displacement in meters.

D. ACCURACY

The accuracy depends upon the operator, the eyepiece magnification, and the dial gauge. A value of 0.1 diopter is anticipated.

TEST DESIGNATION FOCUS TEST NO. 6

A. MEASUREMENT PERFORMED

Focus changes due to optical train rotation (such as the rotation of rhomboid arms).

B. EQUIPMENT

1. A suitable target, preferably a high-resolution target (TKC-10).
2. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
3. Diopter telescope (TKC-1).
4. Data sheet for Focus Test No. 6 given in Section IV.

C. PROCEDURE

Use an eyepiece furnished with the instrument (10X or the closest to this), and the highest power objective that can be used with the arm being tested (some arms and objectives may be a single integral unit). If the instrument has more than one arm, each must be individually tested. Turn the zoom adjustment (if there is one) to its highest magnification. Each right optical train will be tested with the arm in the three positions 12, 3, and 6. Each left optical train will be tested with the arm in the three positions 12, 9, and 6 (see Figure 1). If the 3 or 12 positions cannot be attained in the instrument, then maximum clockwise and counterclockwise positions will be used and their approximate locations noted on the data sheet.

1. The arm being tested is first rotated to either the 3 or 9 position (depending on whether it is a right or left arm). It is then focused on the target by means of the instrument focus control while viewing with the aid of an adjusted* diopter telescope.

2. Bring dial indicator into contact with a surface that will move with further focus adjustments.

3. Adjust the gauge to obtain a dial indicator value of "0". Record this value on the data sheet.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

4. Rotate arm to the 12 position and refocus, on the target, using the instrument focus control while viewing through the diopter telescope.
5. Record the change in the dial indicator reading from the "0" position.
6. Repeat steps 4 and 5 for the arm in the 6 position.
7. Repeat steps 1 through 6 for the other arm.
8. Convert all dial gauge readings to metric units where 0.001 in. = 25.4 micrometers.

D. ACCURACY

The accuracy depends upon the instrument's depth of field. However, with practice, ± 0.001 in. should be obtainable at the higher magnifications.

TEST DESIGNATION RESOLUTION TEST NO. 1

A. MEASUREMENT PERFORMED

Maximum on-axis resolution

Note: Refer to "Reading Resolution Bar-Targets" in Section II.

B. EQUIPMENT

1. Resolution target (TKC-10 or TKC-11).
2. Diopter telescope (TKC-1).
3. Data sheet for Resolution Test No. 1 given in Section IV.

C. PROCEDURE

The highest instrument magnification is to be selected. This includes, where applicable, the highest zoom magnification, the highest power objective, and the highest power eyepiece supplied with the instrument. For instruments with rotatable rhomboid or other types of rotatable extension arms, the arms are to remain in either the 3 or 9 position throughout the test. Each optical train will be viewed and evaluated separately.

1. Adjust* the diopter telescope to standardize the user's vision.
2. Illuminate the target as recommended by the manufacturer for normal imagery.
3. Place the high-resolution elements so that the position of the highest resolution element that can be resolved will be near the center of the field of view.
4. Focus on the resolution target, using the instrument focus control, while viewing through the diopter telescope.
5. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
6. For binocular instruments, repeat steps 2 through 5 on the other optical train.

Note: The same eye must be used for all measurements.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

TEST DESIGNATION RESOLUTION TEST NO. 2

A. MEASUREMENT PERFORMED

Resolution versus magnification (or empty magnification check)

Note: Refer to "Reading Resolution Bar-Targets" in Section II.

B. EQUIPMENT

1. Resolution target (TKC-10 or TKC-11).
2. Diopter telescope (TKC-1).
3. Data sheet for Resolution Test No. 2 given in Section IV.

C. PROCEDURE

The highest instrument magnification is to be selected. This includes, where applicable, the highest zoom magnification, the highest power objective, and the highest power eyepiece supplied with the instrument. For instruments with rotatable rhomboid or other type of rotatable extension arms, the arms are to remain in either the 3 or 9 position throughout the test.

1. Adjust* the diopter telescope to standardize the user's vision.
 2. Illuminate the target as recommended by the manufacturer for normal imagery.
 3. Place the high-resolution elements so that the position of the highest resolution element that can be resolved will be near the center of the field of view.
 4. Focus on the resolution target, using the instrument focus control, while viewing through the diopter telescope.
 5. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
 6. Repeat steps 3 through 5 for every combination of components that control the instrument's magnification. This includes all objectives and selected discrete values.
- *Adjustments and directions for the use of a diopter telescope are contained in Section II.

of zoom magnification (five are recommended) covering the entire zoom range.

7. For binocular instruments, repeat steps 2 through 6 on the other optical train.

Note: The same eye must be used for all measurements.

TEST DESIGNATION RESOLUTION TEST NO. 3

A. MEASUREMENT PERFORMED

Off-axis resolution in instruments with fixed-position objectives*

Note: Refer to "Reading Resolution Bar Targets" in Section II.

B. EQUIPMENT

1. Resolution target, preferably one with both horizontal and vertical bar patterns. Otherwise, the target must be rotated in order to evaluate both tangential and sagittal resolution (TKC-10 or TKC-11).

2. Data sheet for Resolution Test No. 3 given in Section IV.

Note: Loss of resolution off-axis is normally attributable to two qualities. First, a lens is normally optimized for maximum resolution on or near the optical axis at the sacrifice of resolution off-axis. Secondly, the best focus of the image of a flat object is sometimes a curved surface. Thus, lack of field flatness can contribute to an apparent loss of resolution off-axis.

For viewing instruments such as the microscope, the eye can accommodate a certain depth of field or field curvature with no loss of resolution. However, the use of the diopter telescope removes most of the eye's accommodation for depth of field.

3. Although the diopter telescope would enhance the resolution capability of an eye for images sharply in focus, it might actually decrease the ability of the eye to resolve slightly out-of-focus off-axis images. It is therefore important that, when examining off-axis imagery in relation to on-axis imagery, the diopter telescope is not used. It is true that on-axis resolution figures from this test may in some cases not agree with the maximum values obtained in previous tests. However, the relation between on-axis and off-axis resolution will be more representative of actual instrument performance when evaluated in this manner.

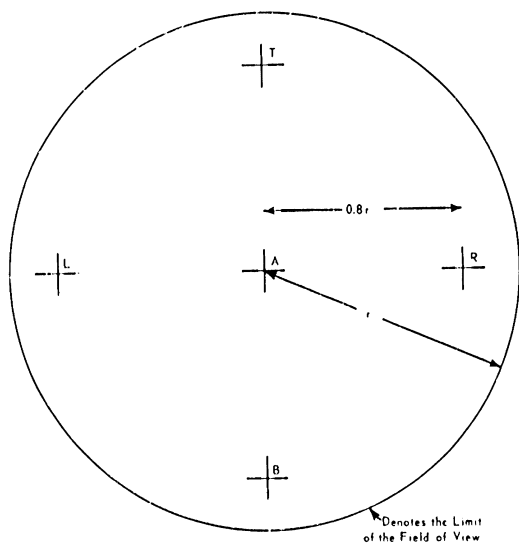
*Instruments in which the objective (once in place) cannot be rotated or displaced without removing it from the optical path.

C. PROCEDURE

The resolution will be evaluated for all eyepiece and objective combinations at maximum zoom magnification (if the instrument has zoom capability). In addition, if there is a zoom mechanism, its effect on off-axis resolution will be determined by readings taken at 5 preselected zoom magnifications, covering the entire zoom range, while using the highest power objective and the highest power eyepiece. Each optical train will be viewed and evaluated separately. Select the optical components and zoom setting that yield the highest instrument magnification.

1. Illuminate the target as recommended by the manufacturer for normal imagery.
2. Place resolution target in position "A" as shown in Figure 2. The target, if not specifically designed to cover the format, will require movement to each of the off-axis positions.
3. Focus on the target using the instrument focus control.
4. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
5. Repeat steps 2 and 4 for the positions B, T, L, and R, as shown in Figure 2. Do not refocus.
6. Repeat steps 2 through 5 for each of the four remaining zoom magnifications. (Omit this step if the instrument does not have zoom magnification capability.)
7. Repeat steps 2 through 5 for each of the remaining combinations of objectives and eyepieces at the maximum zoom magnification.
8. For binocular instruments, repeat steps 2 through 7 on the other optical train. The same eye must be used for all measurements.

Note: Tangential and sagittal resolution values will be obtained for each of the off-axis format positions. Also, the focus should be adjusted only for the "A" position and not for the other format positions.



Each of the off-axis positions L, R, T, and B is to be approximately 0.8 of the distance from the center to the edge of the field of view.

Figure 2. Format Locations For Resolution Measurements

TEST DESIGNATION RESOLUTION TEST NO. 4

A. MEASUREMENT PERFORMED

Off-axis resolution in instruments with rotatable objective arms.

Note: Refer to "Reading Resolution Bar-Targets" in Section II.

B. EQUIPMENT

1. Resolution target, preferably one with both horizontal and vertical bar patterns. Otherwise, the target must be rotated in order to evaluate both tangential and sagittal resolution (TKC-10 or TKC-11).
2. Data sheet for Resolution Test No. 4 given in Section IV.

Note: Loss of resolution off-axis is normally attributable to two qualities. First, a lens is normally optimized for maximum resolution on or near the optical axis at the sacrifice of resolution off-axis. Secondly, the best focus of the image of a flat object is sometimes a curved surface. Thus, lack of field flatness can contribute to an apparent loss of resolution off-axis.

For viewing instruments such as the microscope, the eye can accommodate a certain depth of field or field curvature with no loss of resolution. However, the use of the diopter telescope removes most of the eye's accommodation for depth of field. Thus, although the diopter telescope would enhance the resolution capability of an eye for images sharply in focus, it might actually decrease the ability of the eye to resolve slightly out-of-focus off-axis images. It is therefore important that, when examining off-axis imagery in relation to on-axis imagery, the diopter telescope is not used. It is true that on-axis resolution figures from this test may in some cases not agree with the maximum values obtained in previous tests. However, the relation between on-axis and off-axis resolution will be more representative of actual instrument performance when evaluated in this manner.

C. PROCEDURE

The resolution will be evaluated for all eyepiece and objective combinations at maximum zoom magnification (if the instrument has zoom capability). In addition, if there is a zoom mechanism, its effect on off-axis resolution will be determined by readings taken at 5 preselected zoom magnifications, covering the entire zoom range, while using the highest power objective and the highest power eyepiece. Each optical train will be viewed and evaluated separately.

Select the optical components and zoom setting that yield the highest instrument magnification and attach and rotate one arm to either the 3 or the 9 position (see Figure 1).

1. Illuminate the target as recommended by the manufacturer for normal imagery.
2. Place resolution target in position "A" as shown in Figure 2. The target, if not specifically designed to cover the format, will require movement to each of the off-axis positions.
3. Focus on the target using the instrument focus control.
4. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
5. Repeat steps 2 and 4 for the positions B, T, L, and R, as shown in Figure 2. Do not refocus.
6. Repeat steps 2 through 5 for each of the four remaining zoom magnifications. (Omit this step if the instrument does not have zoom magnification capability.)
7. Repeat steps 2 through 5 for each of the remaining combinations of arms, objectives, and eyepieces for the same optical train.
8. Again, select the optical components that yield the highest instrument magnification and attach and rotate the same arm to the 12 position (see Figure 1).
9. Repeat steps 1 through 5.
10. Rotate arm to the 6 position (see Figure 1) and repeat steps 1 through 5.

11. For binocular instruments, repeat steps 1 through 10 on the other optical train. The same eye must be used for all measurements.

TEST DESIGNATION DISTORTION TEST NO. 1

A. MEASUREMENT PERFORMED

Stereo image distortion

B. EQUIPMENT

1. Two square grids (distortion free) that will fill the field-of-view of the instrument. They should provide at least 10 grid lines in each direction within the field-of-view (TKC-7 or TKC-8).

2. Clear glass plate (TKC-36).

3. Data sheet for Distortion Test No. 1 is given in Section IV.

C. PROCEDURE

This test is very subjective and, thus, will not be outlined following the numerical format used in previous tests.

This test is to be applied to stereoscopic or hyperstereoscopic instruments only. Stereomicroscopes require the use of only a single target grid. Microstereoscopes require two target grids to be used, one for each optical axis. The targets should be rotated and adjusted until, when viewing with both eyes, the images from the two optical trains can be fused easily by the user. The instrument should be evaluated in a variety of configurations varying the eyepieces, objectives and zoom magnification (where applicable). Since such variations will probably vary the field-of-view over a considerable range, it may be necessary to use more than one pair of grids with different size squares in order to completely test a single instrument.

This test is designed not to detect an absolute amount of distortion, but, rather, a difference in distortion between the left and right optical trains. A difference in distortion will cause a slight difference in the spatial configuration of the two images of the two grids. This difference will produce a false sense of depth in the flat grids. Thus, if at any magnification the grid appears to be a curved surface rather than a flat one, the apparent contour of the surface should be described and the instrument component configuration should be recorded.

If the grid (when viewed stereoscopically) appears flat at all magnifications, it shall be reported that the instrument has no apparent stereo distortion. It is recommended that several experienced observers perform this test on an instrument since the evaluation is both highly subjective and qualitative. It should be noted that this test, in contrast to most of the others, involves binocular viewing. Most other tests evaluate a single optical train at a time.

D. ACCURACY

This is a subjective, user-oriented test and the accuracy cannot be specified.

TEST DESIGNATION DISTORTION TEST NO. 2

A. MEASUREMENT PERFORMED

Subjective optical train distortion

B. EQUIPMENT

1. One square grid target (distortion free) that will fill the field-of-view of the instrument. It should provide at least 10 grid lines in each direction within the field-of-view (TKC-5, TKC-7, or TKC-8).
2. An eyepiece compatible with the instrument and containing a grid reticle. The square grid reticle should be selected to provide a compatible overlay to the square grid target at the instrument magnification selected (TKC-2 and TKC-5, or TKC-6).
3. Clear glass plate (TKC-36).
4. Data sheet for Distortion Test No. 2 is given in Section IV.

Note: The square grid reticle, TKC-5, can be utilized as either a reticle or a grid target for high instrument magnification values.

C. PROCEDURE

This test is very subjective and, therefore, will not be outlined following the numerical format used in previous tests.

This test is to be applied to each individual optical train. The grid target or the eyepiece, with its enclosed grid reticle, should be rotated and adjusted until the eyepiece reticle aligns with the grid target. Note that an exact superposition of the eyepiece reticle to the grid target may not be possible due to the presence of instrument distortion or to a change in scale due to the instrument's magnification value.

The instrument should be evaluated in a variety of configurations which vary the objectives, optical prisms and arms, and zoom magnification (where applicable). Since such variations will probably vary the field-of-view over a considerable range, it may be necessary to use more than one grid target.

This test is designed to subjectively determine the presence or absence of distortion in each optical train of the instrument rather than quantitatively measure the magnitude of distortion. The presence of distortion will cause a spatial mismatch between the grid target and the grid reticle that changes across the field-of-view of the instrument. The mismatch will be emphasized by curved grid target lines with respect to the grid reticle and will probably be most noticeable along the edge of the instrument's field-of-view. If at any value of magnification this mismatch in the grid overlays occurs, the apparent contour of the superimposed grids should be described and the instrument component configuration should be recorded.

If the superimposed grids do not emphasize curved grid lines, then it shall be reported that the instrument has no apparent optical train distortion. It is recommended that several experienced observers perform this test on an instrument since the test is both highly subjective and qualitative.

D. ACCURACY

This is a subjective, user-oriented test and the accuracy cannot be specified.

TEST DESIGNATION ASTIGMATISM TEST NO. 1

A. MEASUREMENT PERFORMED

Subjective optical train astigmatism

B. EQUIPMENT

1. Crossline astigmatism target (TKC-12).
2. Diopter telescope (TKC-1).
3. Dial gauge (0.001 in.) and adjustable stand (TKC-20).
4. Data sheet for Astigmatism Test No. 1 given in Section IV.

C. PROCEDURE

The highest instrument magnification is to be selected. This includes, where applicable, the highest zoom magnification, the highest power objective, and the highest power eyepiece supplied with the instrument. For instruments with rotatable rhomboid or other type of rotatable extension arms, the arms are to remain in either the 3 or 9 position throughout the test.

1. Illuminate the target as recommended by the instrument manufacturer for normal imagery.
2. Position the center crossline of the target at the center of the instrument's field-of-view.
3. Focus on the center crossline of the target using the instrument focus control. If a difference between the best focus for the vertical and horizontal crosslines is noticed in some areas of the field-of-view, then astigmatism is present in the instrument and the remaining steps in this test must be carefully followed. If, however, no difference in the best focus for the vertical and horizontal crosslines is noticed in any areas of the field-of-view, then record the absence of astigmatism on the data sheet and proceed to step 11.
4. Note position of crosslines that indicate astigmatism (see Figure 5 on page III-17-1).

III-4-1

5. Adjust* the diopter telescope to standardize the user's vision.

6. Refocus on the center horizontal crossline of the target, using the instrument focus control, while viewing through the diopter telescope.
7. Place the dial gauge in contact with a surface on the instrument that will move with the focus control and adjust the gauge to a dial indicator value of "0".
8. Focus on the center vertical crossline of the target, using the instrument focus control, while viewing through the diopter telescope.
9. Record any change in the dial indicator reading from the "0" position.
10. Repeat steps 5 through 9 for each of the crosslines that indicated the presence of astigmatism as recorded in step 4.
11. Repeat testing procedure, starting with step 2, for any other optical trains. If all optical trains have been previously tested, then proceed to step 12.
12. Repeat steps 2 through 11 for the minimum value of instrument zoom magnification.
13. Repeat steps 2 through 12 for each of the instrument's remaining objectives, extension arms, and eyepieces.
11. Convert all dial gauge values to metric units where 0.001 in. = 25.4 micrometers.

D. ACCURACY

This is a subjective, user-oriented test and the accuracy cannot be specified.

*Adjustments and directions for use of the diopter telescope are contained in Section II.

III-4-2

TEST DESIGNATION ALIGNMENT TEST NO. 1

A. MEASUREMENT PERFORMED

Image decentration through rotatable optical components; paracentration.

B. EQUIPMENT

1. A crossline target with crosslines of 50-micron width or less (TKC-12).
2. An eyepiece compatible with the instrument and containing a reticle accurately centered in the eyepiece with concentric rings in 0.5-mm diameter increments or less, ranging from 0.5-mm diameter or less to 12-mm diameter (TKC-2 and TKC-4).
3. Data sheet for Alignment Test No. 1 is given in Section IV.

C. PROCEDURE

This test is to be applied to a single optical train of an instrument with a rotatable optical component. The component (such as a pechan prism) may provide the ability within an instrument to rotate the images presented to each eyepiece (in binocular instruments) either simultaneously, independently, or both. The test may in general be applied to any optical component through which the image passes and which can be rotated about the optical axis.

The choice of objectives is arbitrary; however, it must be recorded.

The zoom magnification is also arbitrary; however, it must be recorded and not changed throughout the test. It is not necessary to test the system with other combinations of zoom or objective magnifications.

1. Focus a single optical train, using the instrument focus control, on the crossline target. The target must be positioned so that its image is superimposed on the center of the eyepiece reticle.
2. While observing this image, rotate the member being tested a complete 360°, or to the extremities of its movement in both the counterclockwise and clockwise directions if this is less than 360° of rotation. A displacement of the center of the crossline with respect to the center of the reticle is image decentration.

3. Measure the amount of decentration to the nearest reticle ring and record at each 45° increment of rotation. In addition to the magnitude, the approximate direction of the image displacement with respect to the reticle should be recorded. Note that components such as pechan prisms will rotate the target; this is not to be confused with a linear displacement.

4. Repeat steps 1 through 3 for the other optical train on binocular instruments.

D. ACCURACY

The accuracy, as measured in the eyepiece focal plane, should be \pm the difference in the radii of any two adjacent rings in the eyepiece reticle or 0.5 mm.

TEST DESIGNATION: ALIGNMENT TEST NO. 2

A. MEASUREMENT PERFORMED

Zoom image shift and jump, or zoom parfocalization

B. EQUIPMENT

1. A crossline target with cross lines of 50-micron width or less (TKC-12).
2. An eyepiece compatible with the instrument and containing a reticle with both a horizontal and a vertical scale crosshair at the center. Each scale should be a minimum of 5 mm in length and have a precision (smallest division) of 0.1 mm or smaller (TKC-2 and TKC-3).
3. Data sheet for Alignment Test No. 2 is given in Section IV.

C. PROCEDURE

The instrument zoom is to be turned to its highest magnification. Choice of objectives is arbitrary but must be recorded.

1. Focus the instrument sharply on the crossline target and move the target to align exactly with the cross scale eyepiece reticle (the reticle scales should appear approximately vertical and horizontal).
2. While viewing the target, turn the zoom control to obtain minimum magnification. Record any displacement of the target crosslines, with respect to the reticle scales, in terms of the X and Y components. Also, record the zoom magnification setting for each measurement displacement. Systems equipped with selectable discrete magnification relay lenses should be evaluated at each discrete magnification level.
3. Change the direction of the zoom control rotation and closely observe the crossline target. Any abrupt shift or jump in the image position associated with the change in direction should be recorded in terms of its direction and approximate magnitude. This particular phase of this test does not apply to systems with discrete relay magnifications.

Note: Some difficulty may be experienced in zoom or other relay systems that are not exactly parfocalized. In running from one end of the zoom to the other, the image may go out of focus. If this happens, it may be difficult to measure the position of the defocused image. In this case, make a note of the difficulty and make a best estimate of the position of the defocused image. Refocusing the instrument adds another variable to the experiment and should be avoided unless it is absolutely impossible to estimate the position any other way.

D. ACCURACY

The accuracy will be determined by the accuracy of the reticle, 0.1 mm or better, if the instrument is exactly parfocalized. However, some lack of parfocalization may exist and thus make it impossible to predict the accuracy on some instruments.

TEST DESIGNATION ALIGNMENT TEST NO. 3

A. MEASUREMENT PERFORMED

Phoria

Note: Phoria is an anomaly of stereomicroscopes and binocular microscopes where only a single object is viewed. Instruments that can be used as microstereoscopes and also as stereomicroscopes should be operated in the stereomicroscope configuration during this test.

B. EQUIPMENT

1. A crossline target with crosslines of 50-micron width or less (TKC-12).
2. An eyepiece compatible with the instrument and containing a reticle with both a horizontal and a vertical scale crossed at the center. These scales should be a minimum of 5 mm in length each and have a precision (smallest division) of 0.1 mm or smaller (TKC-2 and TKC-3).
3. Data sheet for Alignment Test No. 3 is given in Section IV.

C. PROCEDURE

The objective selection is arbitrary but must be recorded. Zoom magnification should be turned to maximum and remain there.

1. Place eyepiece in the right ocular. If this is a focusable ocular, place the eyepiece in the other ocular. If both oculars are focusable, initiate the test by placing the eyepiece in the right ocular and position ocular at its approximate midpoint position.
2. Using the instrument control, focus the optical train containing the eyepiece and reticle on the crossline target. Make sure that the image of the target is not rotated with respect to the target. If it is, rotate the pechan prism to correct the image orientation. Then adjust the location of the target to a vertical and horizontal position and superimpose it on the eyepiece reticle cross scales.
3. Move the eyepiece (and reticle) to the other ocular and use the eyepiece focus adjustment to bring the image of the target in sharp focus. Check the orientation of

the image without moving the target. If necessary, rotate the pechan prism to correct the image orientation to horizontal and vertical position.

4. Rotate the eyepiece so that the image crosslines and the reticle cross scales are either overlaid or parallel.

5. Record any linear displacement of the center of the crossline image with respect to the reticle cross scales in terms of the X and Y distances displaced.

Note: Although it is not likely, some instruments may not be provided with the ability to rotate the image in one optical train with respect to the other. If this is the case, any rotational displacement of one image with respect to the other must be measured in addition to any linear displacement. To do this, two eyepieces and two reticles are required.

The first eyepiece reticle should have a crossline through the center and 360° protractor scale around the circumference (1° increments should be sufficient). The right ocular should contain the eyepiece with this reticle. The left ocular should contain an eyepiece with simply a crossline reticle. Without a target, the operator must look through both oculars stereoscopically and rotate the two eyepieces until the reticle crosslines appear to be overlaid exactly (the eyes can easily fuse the two images into one). Once this adjustment has been made, the eyepieces must not be rotated during the remainder of the test. Then, looking through the left eyepiece only, focus on the target and place it so that its image exactly lines up with the left eyepiece reticle crosslines. Next, without moving the target, view through the right optical train and record (in degrees) any rotational disparity between the image crosslines and the right eyepiece reticle.

D. ACCURACY

The accuracy depends on the operator's skill. It is estimated that, with some practice, the measurement will be correct to within ± 0.1 mm.

TEST DESIGNATION ALIGNMENT TEST NO. 4

A. MEASUREMENT PERFORMED

Vignetting of optical trains

B. EQUIPMENT

1. Transparent or translucent scale determined by the field-of-view.

Field-of-View	TKC
Less than 5.0 mm	13 or 15
5.0 mm to 10.0 mm	3
10.0 mm to 20.0 mm	14, 16 or 17
20.0 mm to 50.0 mm	14, 16 or 17

2. Data sheet for Alignment Test No. 4 is given in Section IV.

C. PROCEDURE

The lowest power eyepiece, preferably a wide-field eyepiece, supplied with the instrument must be used throughout the test. Place any zoom capability of the instrument at its lowest setting. (Each selectable discrete relay magnification should be evaluated separately.)

1. Attach one pair of extension arms and objectives on the instrument.
2. Switch the illumination level of the instrument to its highest value. It is not necessary to focus the instrument.
3. View one optical train while rotating each movable component. Take note of any displacement in the edges of the field-of-view. If vignetting occurs through the rotation of a component, the appearance of the field will change similarly to that shown in Figure 3. Visually determine the positions of the rotatable elements when vignetting appears most pronounced.
4. Measure the field-of-view, using the appropriate scale, in the directions shown in Figure 3. These figures represent the amount of vignetting.

III-5-7

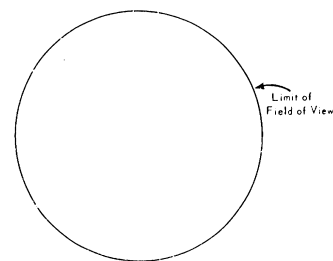


Illustration No. 1 - No Visible Vignetting

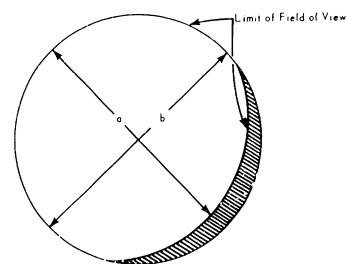


Illustration No. 2 - Maximum Visible Vignetting

Figure 3 Vignetting

III-5-8

5. Repeat steps 2 through 4 for the other optical train.

6. Repeat steps 1 through 5 for each pair of extension arms, objectives, and alternate attachments.

D. ACCURACY

The accuracy depends on the precision of the scale. Since vignetting has a much smaller value than the total field-of-view, the accuracy will be less, on a percentage basis, than the field-of-view measurement. However, the mere detection of vignetting is frequently sufficient and thus the accuracy of this measurement should not be considered critical.

TEST DESIGNATION PARALLAX TEST NO. 1

A. MEASUREMENT PERFORMED

Subjective parallax

Note: This test is intended to provide a subjective method of measuring annoying parallax that creates an apparent height difference between the object imagery and some pointer, fiducial mark, or other reference point or scale internal to the instrument which should appear to be in the same plane as the imagery. In addition to eyepiece reticles, this includes movable and fixed pointers, internal to the instrument, used to specify particular locations in the field-of-view. Most instruments provide ways in which parallax from such devices, particularly eyepieces, can be removed. However, there are some systems in which (under certain conditions) parallax cannot be conveniently removed through normal operation. One such instance might occur when adjustments can be made to eliminate parallax at a fixed zoom magnification but not for other zoom magnifications without readjustment.

B. EQUIPMENT

1. Suitable target scale (0.1-mm divisions or smaller) or stage micrometer of similar precision (TKC-13 or TKC-15).

2. Data sheet for Parallax Test No. 1 is given in Section IV.

C. PROCEDURE

A check for parallax must be made under typical operating conditions after having first removed any residual parallax according to the manufacturer's operating and maintenance manual.

1. Focus one optical train on the target.
2. To detect parallax, move one eye across the exit pupil of the eyepiece (across the field-of-view) and observe any relative motion between the pointer, reference mark, or fiducial mark and the scale on the target.
3. Record any relative movement in terms of the target scale distance.

4. Repeat steps 1 through 3 for the other optical train.

D. ACCURACY

Since this is purely a subjective determination, it is not possible to clearly specify accuracy in this test.

TEST DESIGNATION MAGNIFICATION TEST NO. 1

A. MEASUREMENT PERFORMED

Instrument magnification exclusive of eyepieces. *

B. EQUIPMENT

1. Eyepiece compatible with instrument to be tested and equipped with calibrated 10-mm reticle scale divided into 0.1-mm increments (TKC-2 and TKC-3).

2. Stage micrometer or other calibrated scale.

<u>Magnification (exclusive of eyepiece)</u>	<u>TKC</u>
Less than 1.4	14
1.4 to 3.2	13
Greater than 3.2	13 or 15

C. PROCEDURE

The magnification must be measured in each optical train separately and for all combinations of objectives and each of 3 preselected zoom magnifications (if a zoom is incorporated). The zoom magnifications selected must contain both the maximum and the minimum magnification levels provided by that device, and one other magnification level.

1. Place eyepiece and reticle in one optical train.
2. Focus optical train on the target scale or stage micrometer.
3. Adjust position of target until its image is superimposed on the reticle scale along the length of the scales.
4. Record the length of overlap for each scale. The ratio of the length of overlap on the reticle scale to the length of overlap on the target scale is equal to the magnification.

*Eyepiece magnification measurements require sophisticated laboratory environments and procedures which are beyond the scope of the manual.

D. ACCURACY

With the scales indicated in the equipment section (Par. B above) the accuracy should be better than 2 percent for all magnifications (exclusive of the eyepiece) between 0.3X and 15.0X.

TEST DESIGNATION NUMERICAL APERTURE TEST NO. 1

A. MEASUREMENT PERFORMED

Numerical aperture (N.A.) of a single optical train.

B. EQUIPMENT

1. Pinhole circular aperture. Should be in material of thickness between 0.002 in. and 0.003 in. and the diameter should be between 0.0075 in. and 0.0150 in.
2. Target scale (TKC-3, TKC-13 or TKC-14)
3. Handheld magnifier 10X or higher or an eyepiece (TKC-2 or TKC-33).
4. A stand to hold the pinhole on the instrument stage between 1.25 and 1.75 in. above the glass scale.
5. Data sheet for Numerical Aperture Test No. 1 is given in Section IV.

C. PROCEDURE

The procedure to be followed will determine the numerical aperture using the equipment set up as shown in Figure 5. The choice of eyepieces is arbitrary although the same eyepiece should be used throughout the test.

1. Select the appropriate glass scale, from those given below, and place it on the instrument substage.

N. A. Range	TKC
Less than 0.065	3 or 13
0.065 to 0.26	3 or 14

2. Switch on the highest illumination available from the instrument substage.
3. Place pinhole aperture above the glass scale (approximately 1.25 to 1.75 in.).

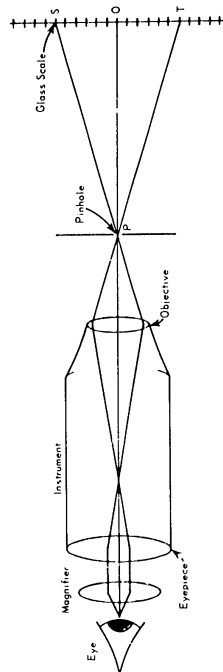


Figure 4. Measurement of Instrument Numerical Aperture

4. Focus one optical train of the instrument on the pinhole aperture. Do not refocus the instrument until reaching step 9.
5. Using the auxiliary handheld magnifier, examine the exit pupil of the instrument's eyepiece for the optical train being tested. The glass scale will come into view when the eye and the magnifier are properly aligned along the optical axis (the glass scale on the substage may also require alignment).
6. Record the visible distance of the substage scale as the value ST as shown in Figure 5.
7. Measure and record the distance between the pinhole and the scale, P/O , to the nearest 0.01 in.
8. Calculate the numerical aperture using the formula:

$$N.A. = N \sin \theta$$
 where:

$$N \text{ in air: } N = 1.0$$

$$\theta = \tan^{-1} \frac{ST}{2 P/O}$$
9. Repeat steps 1 through 8 for all objectives available with the instrument and at both the maximum and minimum zoom magnifications for each objective. If instrument incorporates selectable discrete magnification relay lenses, repeat steps 1 through 8 for all combinations of objectives and relay lenses.
10. Repeat steps 1 through 9 for the other optical train.

D. ACCURACY

The accuracy will depend to a certain extent on the person performing this test. However, with practice, accuracy should be better than 2 percent for N.A. between 0.065 and 0.26, using the 10-mm scale. To increase the accuracy for numerical apertures less than 0.065, a 5-mm scale with 100 divisions of 0.01 mm each can be used to provide 2 percent accuracy or better down to a N.A. = 0.0325. For N.A. greater than 0.26, the longest scale would have to be used.

TEST DESIGNATION FIELD-OF-VIEW TEST NO. 1

A. MEASUREMENT PERFORMED

Field-of-view by direct measurement

B. EQUIPMENT

1. Appropriate transparent or translucent scale according to chart:

<u>Field-of-View</u>	<u>TKC</u>
Less than 5 mm	13 or 15
5.0 mm to 10.0 mm	3
10.0 mm to 20.0 mm	14, 16 or 17
20.0 mm to 50.0 mm	14, 16 or 17

2. Data sheet for Field-of-View Test No. 1 is given in Section IV.

C. PROCEDURE

1. Place the most precise scale that will extend across the entire field-of-view onto the instrument stage.
2. Bring the scale into sharp focus and position it in the center of the field of one of the optical trains.
3. Record the visible range on the scale as the field-of-view.
4. Repeat steps 1 through 3 for every combination of objective, eyepiece and maximum and minimum zoom magnifications. Instruments containing discrete selectable magnification relay lenses should be tested at every combination of objective, relay and eyepiece lenses.
5. Repeat steps 1 through 4 for the other optical train.
6. If an English scale is used, convert to millimeters where 1 in. = 25.4 mm.

D. ACCURACY

Determined by the scale precision. The scales suggested in the equipment should provide a minimum of 1.5 percent accuracy.

TEST DESIGNATION ILLUMINATION TEST NO. 1

A. MEASUREMENT PERFORMED

Illumination measurement of large-area diffuse sources

B. EQUIPMENT

1. Weston Master V Universal Exposure Meter (TKC-25)*.
2. Data sheet for Illumination Test No. 1 given in Section IV.

C. PROCEDURE

The purpose of this test is to obtain an approximate measure of the illumination level of microstereoscope light sources, such as light tables. An additional purpose is to determine the uniformity of the illumination across the surface of the source.

1. Set source illumination level as specified by the instrument's manufacturer for normal viewing operation.
2. Place Weston meter on instrument's light table in a position corresponding to the center of the field-of-view of the instrument.

Note:

- a. The photoelectric cell of the meter must be parallel to the light table surface.
 - b. The hinged baffle** should be initially closed to utilize the highest light scale.
3. Depress pointer lock** button, located on the right side of light scale, and record the meter light-scale reading.

Note:

- a. The meter light scale must always face the same direction for all readings taken. The preferred direction is towards the front of the instrument.

*Refer to the General Testing Guidelines for the Illumination Meter, Section II-B, pg. II-7.

**Refer to Weston Master V Instruction booklet.

- b. If the light-scale reading is below a value of 10, open the hinged baffle to obtain the lowest light scale and record this scale reading.
4. Repeat steps 2 and 3 for several other positions on the light table.
5. Convert all meter light-scale readings to foot-candles using the meter's Calibration Conversion Chart.

D. ACCURACY

The accuracy of this test is dependent upon the accuracy of the values given in the Calibration Conversion Chart.

TEST DESIGNATION SPECTRAL FILTER TEST NO. 1

A. MEASUREMENT PERFORMED

Spectral filter effects on resolution

B. EQUIPMENT

1. Spectral filters (TKC-29).
2. Resolution target (TKC-10).
3. Data sheet for Spectral Filter Test No. 1 given in Section IV.

C. PROCEDURE

Spectral effects will be evaluated using a test similar to Resolution Test No. 2. However, the instrument resolution will now be determined for the three spectral filters and the diopter telescope will not be used.

Select the optical components and zoom setting that yield the highest instrument magnification and attach and rotate one arm to either the 3 or the 9 position (see Figure 1, pg. III-1-2).

1. Place green spectral filter over instrument light source.
2. Illuminate resolution target as recommended by the manufacturer for normal imagery.

Note: The base of the resolution target may have to come in contact with the spectral filter. Do not place spectral filter in contact with resolution target emulsion.

3. Place resolution target in the center of the field-of-view of the right optical train.
4. Focus on the target using the instrument focus control.
5. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
6. Repeat steps 2 through 5 for each of the two remaining filters.

7. Repeat steps 1 through 6 for each of the remaining combinations of eyepieces, objectives, and extension arms for the right optical train.

8. For binocular instruments, repeat steps 1 through 7 on the other optical train. The same eye must be used for all measurements.

Note: Do not attempt to compare the resolution values obtained in this test to those obtained in Resolution Test No. 2. There may be a difference between these resolution values due to the transmission properties of the spectral filters. Instead, compare the resolution values (of this test) obtained for each of the spectral filters for identical instrument component setups.

Since this is a subjective test, these differences in resolution values can only be used to indicate the general ability of the instrument and the operator to distinguish fine detail in these broad spectral regions.

TEST DESIGNATION POLARIZATION TEST NO. 1

A. MEASUREMENT PERFORMED

Polarization effects on resolution

B. EQUIPMENT

1. Polarizing filter (FKC-28).
2. Resolution target (FKC-10).
3. Data sheet for Polarization Test No. 1.

C. PROCEDURE

Polarization effects will be evaluated using a test similar to Resolution Test No. 4. However, the instrument resolution will now be determined for several orientations of the polarizing filter using all combinations of the optical train extension arms.

Select the optical components and zoom setting that yield the highest instrument magnification and attach and rotate one arm to either the 3 or the 9 position (see Figure 1, pg. III-1-2).

1. Orient polarizing filter over instrument light source so that polarization axis* is parallel to operator (i.e., horizontal position).
2. Illuminate resolution target as recommended by the manufacturer for normal imagery.

Note: The base of the resolution target may have to come in contact with the polarizing filter. Do not place polarizing filter in contact with resolution target emulsion.

3. Place resolution target in the center of the field-of-view of the right optical train

4. Focus on the target using the instrument focus control.

*See orientation label on target.

5. Read and record the largest resolution elements that are just resolved in the tangential and sagittal directions.
6. Rotate the polarization filter 90° , without rotating the resolution target, and repeat steps 3 through 5.
7. Repeat steps 3 through 5 at several other orientations of the polarizing filter without changing the orientation of the resolution target.
8. Repeat steps 3 through 7 for each of the remaining combinations of arms for the right optical train.
9. Repeat steps 3 through 8 with each of the arms in the 12 position (see Figure 1).
10. Repeat steps 3 through 8 with each of the arms in the 6 position (see Figure 1).
11. For binocular instruments, repeat steps 1 through 10 on the other optical train. The same eye must be used for all measurements.

Note: Do not attempt to compare the resolution values obtained in this test to those obtained in Resolution Test No. 4. There may be a difference between these resolution values due to the transmission properties of the polarizing filters. Instead, compare the resolution values (of this test) obtained at the various polarizing filter orientations for identical instrument component setups. Differences in the resolution values are due to the polarization effects of some instrument components.

TEST DESIGNATION INTERPUPILLARY DISTANCE TEST NO. 1

A. MEASUREMENT PERFORMED

Interpupillary distance for binocular instruments using handheld scale

B. EQUIPMENT

1. 10-cm scale on ground glass in 2-mm divisions (TKC-14).
2. Data sheet for Interpupillary Distance Test No. 1 is given in Section IV.

C. PROCEDURE

Switch the illumination to its highest intensity. No target is necessary, although if the illumination is not diffuse, focus the instrument on the stage.

1. Move the ocular separation adjustment to obtain maximum separation of the oculars.
2. Hold the ground glass scale above the eyepieces and adjust its height to obtain the sharply focused images of the two exit pupils. These images will be two small (approximately 2-mm diameter) circular spots of light. The appropriate height will be the eye relief of the eyepiece. This height (the distance along the optical axis from the top of the eyepiece to the exit pupil) will usually be between 1/4 in. and 1 in.
3. Measure the distance between the centers of the exit pupils on the scale and record as the maximum interpupillary distance.
4. Repeat steps 1 through 3 with the ocular separation adjustment closed to obtain the minimum ocular separation. This recorded value is the minimum interpupillary distance.

Note: This experiment does not depend on which objectives, eyepieces and zoom magnifications are used. However, more light is available at lower magnifications and might be helpful.

D. ACCURACY

The accuracy of this test depends not only on the scale precision, but also on the ability of the person performing the test to hold the scale still while reading the locations of both images. It is anticipated that 3 or 4 percent should be attained with a little practice.

TEST DESIGNATION EYE RELIEF TEST NO. 1

A. MEASUREMENT PERFORMED

Eye relief of an instrument using the handheld method.

B. EQUIPMENT

1. Ground glass or opal glass screen (TKC-37).
2. Six-inch machinist scale, with precision of 1.0 mm or better (TKC-17).
3. Data sheet for Eye Relief Test No. 1 is given in Section IV.

C. PROCEDURE

Switch the instrument illumination to its highest intensity. No target is necessary, although if the illumination is not diffuse, the instrument should be focused approximately at the stage. Set the magnification of the instrument to its highest value. (Combine the highest power objective with the highest value of zoom magnification.)

1. Hold the ground or opal glass above the eyepiece and adjust its height until the image of the exit pupil is in sharp focus on the imaging surface of the glass. Note: The imaging surface must be directed down toward the eyepiece.

2. Measure the distance, parallel to the optical axis, from the exit pupil image to the highest surface of the eyepiece, using the machinist scale. This distance is the eye relief of the eyepiece.

3. Repeat steps 1 and 2 with the instrument set at its minimum magnification. Note: The maximum magnification will normally produce the minimum eye relief for a particular eyepiece and the minimum magnification will normally produce the maximum eye relief. Some eyepieces will have an eye relief that does not vary appreciably with magnification. The maximum and minimum eye relief of each eyepiece should be recorded and each eyepiece need only be evaluated on a single optical train.

D. ACCURACY

The accuracy of this test depends not only on the scale precision, but also on the ability of the person performing the test to hold the scale still while reading the locations of both images.

TEST DESIGNATION WORKING DISTANCE TEST NO. 1

A. MEASUREMENT PERFORMED

Working distance between objective and substage.

B. EQUIPMENT

1. An inexpensive or expendable target or any such target that can be easily focused upon (TKC-7 or TKC-14).

2. Dial gauge and adjustable stand. (A dial gauge, accurate to 0.001 in., is recommended for working distances less than 0.2 in. and a small vernier height gauge, accurate to 0.01 in., is recommended for working distances greater than 2.0 in. (TKC-19 or TKC-20).

3. Data sheet for Working Distance Test No. 1 is given in Section IV.

C. PROCEDURE

Set the magnification of the instrument to its highest value. (Combine highest power objective and eyepiece with the maximum zoom magnification setting).

1. Place target on substage with the emulsion, chrome, or other image surface toward the objective.

2. Lower the instrument's optical train, using its focus control, until the objective just contacts the surface of the target.

Caution: This assumes that the objective lens surface is recessed behind the objective's metal rim. The lens surface must not touch the target.

3. Place the dial gauge in contact with a surface on the instrument that will move with the optical train.

4. Record the gauge reading as the initial position.

5. Focus the instrument, using its focus control, on the target.

6. Record the dial gauge reading. The difference between this value and the initial value is the working distance.

7. Repeat steps 1 through 6 for all remaining objectives supplied by the manufacturer.

8. Repeat steps 1 through 7 at the lowest magnification of the eyepiece and minimum zoom setting.

Note: The mechanical design of some instruments may limit the travel of the optical train so that the objective cannot be placed in contact with the object plane. In this case, lower the optical train to its lowest attainable position and measure the distance between the objective and the object plane (using an accurate scale, wedge, or gauge blocks). Then continue with steps 3 through 8.

If an abnormally large depth of field makes it difficult to determine repeatably the location of best focus, the instrument may be focused while using a diopter telescope. An adjusted* diopter telescope can greatly reduce the depth of field and make the focus adjustment more critical.

D. ACCURACY

The accuracy depends upon the operator, the instrument's depth of field, and the precision of the gauge. However, with repetitions, an average value should be obtainable that is accurate within 1 percent.

*Adjustment and directions for the use of a diopter telescope are contained in Section II.

TEST DESIGNATION OPTICAL PATH SEPARATION TEST NO. 1

A. MEASUREMENT PERFORMED

Maximum and minimum X optical path separations, and maximum Y optical path separation.

Note: Measurements are based upon the application of Cartesian coordinate system to the object plane. The X axis is considered horizontal to the operator and the Y axis is perpendicular to the operator.

B. EQUIPMENT

1. An appropriate glass scale, i.e., the scale having the greatest available precision while still being long enough to make the measurement. This measurement depends upon the instrument being tested and can conceivably range from less than 1 in. to nearly 1 ft or more. The precision of the scale should provide at least 100 divisions between the two optical paths (TKC-16 or TKC-17).

2. Data sheet for Optical Path Separation Test No. 1 is given in Section IV.

3. An eyepiece with crosslines should be used if available.

C. PROCEDURE

If the instrument uses rhomboid or other extension arms, each pair should be placed in the instrument and evaluated. Each arm should contain the same objective and eyepiece as its companion arm. The choice of objective, zoom magnification and eyepiece is otherwise up to the operator. A combination that provides easy readability of the scale should be chosen and used throughout the test.

1. Choose and attach to the instrument the pair of extension arms to be evaluated.
2. Adjust the positions of the arms to the minimum X separation (no Y separation) nearest the operator. This can be attained by rotating the right arm clockwise and the left arm counterclockwise until each stops.
3. Place the scale on the substage so that its centerline or edge simultaneously passes through the center of each field-of-view.

4. Focus the right optical train on the scale and record the intersection of the right side of the field-of-view with the scale. *

5. Focus the left optical train on the scale and record the intersection of the right side of the field-of-view with the scale. *

6. Subtract these two values to obtain the minimum X separation.

7. Repeat steps 3 through 6 with the positions of the arms adjusted to the minimum X separation (no Y separation) furthest away from the operator. This can be attained by rotating the right arm counterclockwise and the left arm clockwise until they stop.

8. Repeat steps 3 through 5 with the positions of the arms at the maximum X separation (no Y separation). This should put the arms in the 3 and 9 positions respectively as shown in Figure 1.

9. Subtract these two values to obtain the maximum X separation.

10. Repeat steps 3 through 5 with both arms in the 6 position, as shown in Figure 1.

11. Subtract these two values to obtain the Y separation between the 6 positions.

12. Adjust the positions of the arms to a maximum Y separation. Place the left arm in the 12 position and the right arm in the 6 position as shown in Figure 1.

13. Repeat step 3.

14. Focus the right optical train on the scale and record the intersection of the upper-left side of the field-of-view with the scale. *

15. Focus the left optical train on the scale and record the intersection of the upper-left side of the field with the scale. Subtract these two values to obtain "D" the diagonal separation. *

16. Calculate the maximum Y separation using the formula

$$Y_{max} = (D^2 - X^2)^{1/2}$$

*If a crossline eyepiece is used, the following applies: "Record the intersection of the scale and the center of the eyepiece crosslines."

where Δ_{max} is the maximum Δ separation.

Δ is the difference between the values recorded in steps 12 and 13.
 Δ is the Δ separation obtained in step 11.

17. Repeat steps 11 through 16 with the position of the arms adjusted to obtain the other possible maximum Δ separation. Place the left arm in the 6 position and the right arm in the 12 position. Make the measurements from the upper right intersections.

D. ACCURACY

The accuracy depends upon the precision of the scale and the image centration of the instruments. Provided the image decentration is not significant, 1 percent accuracy or better should be easily attainable.

TEST DESIGNATION ORTHOGONALITY TEST NO. 1

A. MEASUREMENT PERFORMED

System translation and orthogonality

Note: This test applies only to those instruments which allow for translation between the object (film) plane and the optical viewing axis. Also, all measurements are based upon the application of the Cartesian coordinate system to the object plane. The X axis is considered horizontal to the operator and the Y axis is perpendicular to the operator.

B. EQUIPMENT

1. Crossline orthogonality target (TKC-12). (See Figure 5.)
2. Instrument eyepiece with crossline reticle (either a reticle supplied with the instrument's eyepiece or TKC-3).

Note: The use of the instrument eyepiece and a crossline reticle assumes that the instrument has X and Y coordinate indicators. If the instrument does not have these position indicators, then use an eyepiece compatible with the instrument and containing a reticle with a horizontal and a vertical scale crossed at the center (TKC-2 and TKC-3).

3. Data Sheet for Orthogonality Test No. 1.

C. PROCEDURE

1. Illuminate the target as recommended by the instrument manufacturer for normal imagery.
2. Position the center crossline of the target at the center of the crossline reticle.
3. Focus on the center crossline of the target using the instrument focus control. Use both optical trains for a binocular instrument.
4. Position the horizontal lines along the target X axis to align with the instrument's X axis translation. All horizontal crosslines of the target should pass through

the center of the crossline reticle when the system is horizontally translated. Record the value indicated for the instrument's Y axis position (Y_7).

5. Starting with the target crossline to the left of the operator, measure and record the position of each vertical crossline along the X axis translation path of the instrument (X_{1-13}). These horizontal positions must be obtained directly from the instrument's X axis indicator (mechanical scale or electronic readout device) when the vertical components of the target crossline pass through the center of the crossline reticle.

6. Position the center crossline of the target at the center of the crossline reticle using the instrument's X axis translation.

7. Using the instrument's Y axis translation, position the target crossline farthest from the operator so that its horizontal line component passes through the center of the crossline reticle. Record the indicated X and Y axis positions (X_7 , Y_1).

8. Using the instrument's X axis translation, position the vertical component of this target crossline at the center of the crossline reticle. Record the indicated X and Y axis positions (X_{7c} , Y_1).

9. Repeat step 4 and record instrument's X and Y axis positions (X_7 , Y_7).

10. Repeat step 6.

11. Repeat step 7 for the target crossline nearest the operator. Record the indicated X and Y axis positions (X_7 , Y_{13}).

12. Repeat step 8 for the target crossline nearest the operator. Record the indicated X and Y axis positions (X_{7c} , Y_{13}).

13. Position the vertical lines along the target Y axis to align with the instrument's Y axis translation. Record X axis position (X_7).

14. Starting from the target crossline farthest from the operator, measure and record the distance between each horizontal crossline along the Y axis translation path of the instrument (Y_{1-13}). These vertical distances must be obtained directly from the instrument's Y axis indicator when the horizontal components of the target crosslines pass through the center of the crossline reticle.

15. Determine instrument X axis and Y axis translational error. Subtract respective calculated distance values obtained from steps 5 and 14 from the calibrated crossline positions of the target.

16. Calculate instrument's orthogonality error.

Positive Y axis error:

$$\theta_p = \tan^{-1} (\Delta X / \Delta Y)$$

where: $\Delta X = X_7 - X_{7c}$

X_7 = X position recorded in step 7

X_{7c} = X position recorded in step 8

and $\Delta Y = Y_1 - Y_7$

Y_1 = Y position recorded in step 8

Y_7 = Y position recorded in step 4

Negative Y axis error:

$$\theta_n = \tan^{-1} (\Delta X' / \Delta Y')$$

where: $\Delta X' = X_7' - X_{7c}'$

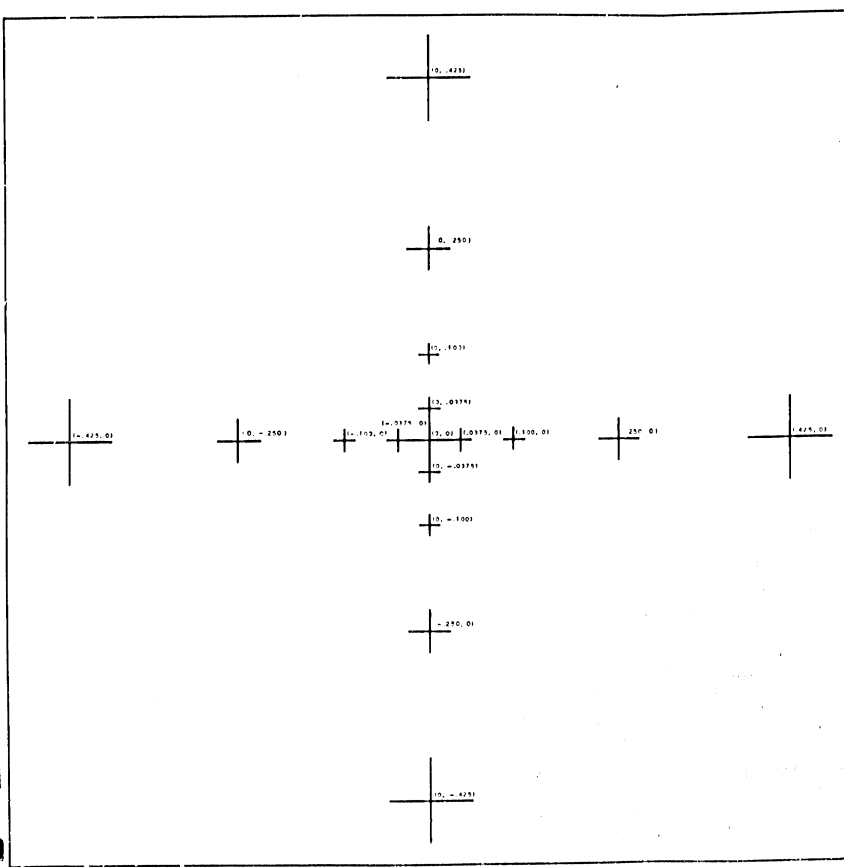
X_7' = X position recorded in step 11

X_{7c}' = X position recorded in step 12

and $\Delta Y' = Y_{13}' - Y_7'$

Y_{13}' = Y position recorded in step 12

Y_7' = Y position recorded in step 9



III-17-4

(x, y) COORDINATES ARE GIVEN IN THE DRAWING FOR REFERENCE ONLY AND ARE NOT TO BE PRINTED ON THE TARGET PLATE.

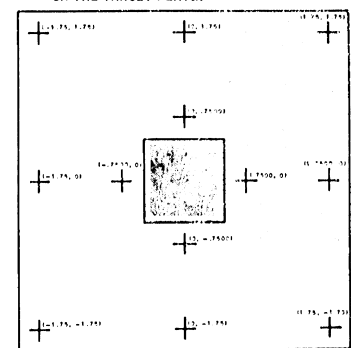


PLATE DIMENSIONS: 4.0" x 4.0"

1" x 1" GRAY AREA ABOVE ENLARGED TO 10X AT LEFT

± .0002" POSITIONAL ACCURACY AT EACH CROSS POINT
 .0002" LINE WIDTH THROUGHOUT

Figure 5 Astigmatism and Orthogonality Targets

TEST DESIGNATION VIBRATION TEST NO. 1

A. MEASUREMENT PERFORMED

Instrument vibration

B. EQUIPMENT

1. Foeppl Vibration Target (TKC-9).
2. Illuminator (TKC-26).
3. Data sheet for Vibration Test No. 1 given in Section IV.

C. PROCEDURE

1. Place target in film plane and illuminate for normal viewing conditions.
2. Position target parallel to the observer and in the center of the field-of-view with the instrument set at a medium value of magnification.
3. Focus the right optical train, using the instrument focus control, on the vibration target.

4. Observe and record the pair of dots which appear to merge into a single dot.

Note: The target consists of 20 pairs of 0.001-inch dots which converge to a single dot. The distance between each pair of dots increases by 0.001 inch to a maximum of 0.02 inch in the last pair. To read the vibration target it is necessary to:

- a. Count the number of dot pairs that can be observed between the single end dot and the pair which appear to merge into a single dot.
 - b. Multiply the number of dot pairs found in "a" by 0.001 inch.
5. Rotate the vibration target to a position that is perpendicular with respect to the operator and the front of the instrument and repeat steps 3 and 4.
 6. Repeat steps 3 and 4 at several other target orientations within the field-of-view.
 7. Repeat steps 2 through 6 using the left optical train of the instrument.

8. Repeat steps 2 through 7 using the illuminator supplied with the optical test kit rather than the instrument's light source.

D. ACCURACY

Accuracy is determined by the precision of target, which is 0.001 inch.

TEST DESIGNATION TENSION TEST NO. 1

A. MEASUREMENT PERFORMED

Film tension on instrument transport.

B. EQUIPMENT

1. Tension tester (TKC-22)
2. Two film leaders with width to match the widest film spool that can be used with the instrument film transport.
3. Hole punch (TKC-23).
4. Data sheet for Tension Test No. 1 given in Section IV.

C. PROCEDURE

1. Place film leaders on instrument film spools.
2. Punch 1 hole at the center of the film leader.
3. Insert hooks of tension tester into set of film leader holes and turn film spools to provide minimum tension on tester.
4. Translate film leader and tension tester with either manual or automatic film transport operation.
5. Record tension indicated by tester.

TEST DESIGNATION SURFACE TEMPERATURE TEST NO. 1

A. MEASUREMENT PERFORMED

Temperature at surface of instrument

B. EQUIPMENT

1. Surface temperature thermometer (TKC-21).
2. Data sheet for Surface Temperature Test No. 1 given in Section IV.

C. PROCEDURE

The surface thermometer can be used to measure the surface temperature of either horizontal or nonhorizontal surface areas. For horizontal surfaces, proper utilization of the thermometer requires only that the instrument surface be flat and smooth to provide firm and uniform contact between the instrument surface and the thermometer.

For nonhorizontal surfaces, however, it is recommended that surface temperature measurements be taken only for flat, "ferrous" instrument surfaces.* The ferrous material of the surface provides for the utilization of the permanent magnet holder supplied with the thermometer.

1. Place the thermometer on the instrument surface to be measured and allow approximately three minutes for it to reach temperature stability. If the magnetic holder is required, place the hole in the magnet spring over the center post of the thermometer. Do not attempt to bolt the magnet down with the nuts on the thermometer.

2. Record temperature measurement on data sheet.

3. Repeat steps 1 and 2 for other surface areas.

*The surface thermometer manufacturer recommends the application of silicone grease to the back of the thermometer to hold it in contact with nonhorizontal, nonferrous surfaces. However, since microstereoscope instruments are designed for use with high-resolution film materials, and may be located in clean room areas, the use of silicone grease must be avoided.

D. ACCURACY

Accuracy is determined by the precision of the surface thermometer, which is $\pm 2^\circ\text{F}$.

SECTION IV
DATA SHEETS

NAME _____ INSTRUMENT _____
DATE _____

I. FOCUS TEST NO. 1

EYEPiece MAGNIFICATION _____

ZOOM MAGNIFICATION _____

	OBJECTIVE MAGNIFICATIONS				
DIAL GAUGE READING					
METRIC CONVERSION					

NAME _____
DATE _____

INSTRUMENT _____

II. FOCUS TEST NO. 2

EYEPiece MAGNIFICATION _____
OBJECTIVE MAGNIFICATION _____

		ZOOM MAGNIFICATIONS									
DIAL GAUGE READING	METRIC CONVERSION										

NAME _____
DATE _____

INSTRUMENT _____

III. FOCUS TEST NO. 3

EYEPiece MAGNIFICATIONS _____
MAXIMUM OBJECTIVE MAGNIFICATION _____

		ZOOM MAGNIFICATIONS									
DIAL GAUGE READINGS	METRIC CONVERSION										

MAXIMUM ZOOM MAGNIFICATION _____

		OBJECTIVE MAGNIFICATIONS									
DIAL GAUGE READINGS	METRIC CONVERSION										

NAME _____ INSTRUMENT _____
 DATE _____

IV. FOCUS TEST NO. 4

EYEPIECE MAGNIFICATION: _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 MAXIMUM ZOOM MAGNIFICATION _____

	INITIAL VALUE	X	X"		
DIAL GAUGE VALUES				D DIOPTERS	D" DIOPTERS
METRIC CONVERSIONS					

NAME _____ INSTRUMENT _____
 DATE _____

V. FOCUS TEST NO. 5

EYEPIECE MAGNIFICATIONS _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 MAXIMUM ZOOM MAGNIFICATION _____

DATA FOR FIRST EYEPIECE				
	INITIAL VALUE	Y	X	X"
DIAL GAUGE VALUES				
METRIC CONVERSIONS				

DATA FOR SECOND EYEPIECE				
	INITIAL VALUE	X	X"	
DIAL GAUGE VALUES				D DIOPTERS
METRIC CONVERSIONS				D" DIOPTERS

NAME _____ INSTRUMENT _____
 DATE _____

VI. FOCUS TEST NO. 6

EYEPiece MAGNIFICATION _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 MAXIMUM ZOOM MAGNIFICATION _____

	RIGHT OPTICAL TRAIN				LEFT OPTICAL TRAIN			
	COMPONENT POSITION				COMPONENT POSITION			
	3	12	6		9	12	6	
DIAL GAUGE READINGS								
METRIC CONVERSION								

NAME _____ INSTRUMENT _____
 DATE _____

VII. RESOLUTION TEST NO. 1

MAXIMUM EYEPiece MAGNIFICATION _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 MAXIMUM ZOOM MAGNIFICATION _____
 UNITS _____

	RESOLUTION READINGS	
	TANGENTIAL	SAGITTAL
RIGHT OPTICAL TRAIN		
LEFT OPTICAL TRAIN		

NAME _____ INSTRUMENT _____
 DATE _____

IX. RESOLUTION TEST NO. 3 (cont'd.)

MAXIMUM ZOOM MAGNIFICATION _____
 RIGHT _____ LEFT _____ OPTICAL TRAIN _____
 TANGENTIAL _____ SAGITTAL _____ RESOLUTION VALUES _____
 UNITS _____

		FORMAT POSITIONS				
		CENTER	BOTTOM	TOP	LEFT	RIGHT
EYEPiece MAGNIFICATION VALUES	OBJECTIVE MAGNIFICATIONS					
	OBJECTIVE MAGNIFICATIONS					
	OBJECTIVE MAGNIFICATIONS					

NAME _____ INSTRUMENT _____
 DATE _____

X. RESOLUTION TEST NO. 4

MAXIMUM EYEPiece MAGNIFICATION _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 EXTENSION ARM NUMBER _____ POSITION _____
 RIGHT _____ LEFT _____ OPTICAL TRAIN _____
 TANGENTIAL _____ SAGITTAL _____ RESOLUTION VALUES _____
 UNITS _____

		FORMAT POSITIONS				
		CENTER	BOTTOM	TOP	LEFT	RIGHT
ZOOM MAGNIFICATIONS						

NAME _____
DATE _____

INSTRUMENT _____

XIV. ALIGNMENT TEST NO. 1

EYEPIECE MAGNIFICATION _____
OBJECTIVE MAGNIFICATION _____
ZOOM MAGNIFICATION _____
UNITS _____

POSITION OF ROTATION	RIGHT OPTICAL TRAIN		LEFT OPTICAL TRAIN	
	DISPLACEMENT		DISPLACEMENT	
	MAGNITUDE	DIRECTION	MAGNITUDE	DIRECTION
0°				
45°				
90°				
135°				
180°				
225°				
270°				
315°				

NAME _____
DATE _____

INSTRUMENT _____

XV. ALIGNMENT TEST NO. 2

EYEPIECE MAGNIFICATION _____
OBJECTIVE MAGNIFICATION _____
UNITS _____

IMAGE DISPLACEMENT	ZOOM MAGNIFICATION									
	Y									
X										

NAME _____ INSTRUMENT _____
 DATE _____

XVIII. PARALLAX TEST NO. 1

EYEPiece MAGNIFICATION _____
 OBJECTIVE MAGNIFICATION _____
 ZOOM MAGNIFICATION _____
 UNITS _____

	RELATIVE DISPLACEMENT	
	X	Y
RIGHT OPTICAL TRAIN		
LEFT OPTICAL TRAIN		

NAME _____ INSTRUMENT _____
 DATE _____

XIX. MAGNIFICATION TEST NO. 1

EYEPiece MAGNIFICATION _____
 UNITS _____

	RIGHT OPTICAL TRAIN			LEFT OPTICAL TRAIN		
	OBJECT SCALE	EYEPiece SCALE	MAGNIFICATION	OBJECT SCALE	EYEPiece SCALE	MAGNIFICATION
OBJECTIVE MAGNIFICATION						
ZOOM MAGNIFICATION						

NAME _____ INSTRUMENT _____
 DATE _____

XXIV. POLARIZATION TEST NO. 1

MAXIMUM EYEPIECE MAGNIFICATION _____
 MAXIMUM OBJECTIVE MAGNIFICATION _____
 MAXIMUM ZOOM MAGNIFICATION _____
 EXTENSION ARM NUMBERS _____
 TANGENTIAL _____ SAGITTAL _____ RESOLUTION VALUES
 UNITS _____

		POLARIZATION TARGET ORIENTATION					
RIGHT OPTICAL TRAIN - ARM POSITION	LEFT OPTICAL TRAIN - ARM POSITION	HORIZONTAL	VERTICAL				
12	12						
6	6						
9	9						
12	12						
6	6						
3	3						

NAME _____ INSTRUMENT _____
 DATE _____

XXV. INTERPUPILLARY DISTANCE TEST NO. 1

UNITS: _____

MAXIMUM SEPARATION		MINIMUM SEPARATION	

NAME _____
DATE _____

INSTRUMENT _____

XXIX. ORTHOGONALITY TEST NO. 1

TRANSLATION DATA:

	HORIZONTAL MEASUREMENT DATA (STEPS 4 AND 5)		HORIZONTAL DISTANCE VALUES ($\Delta X = X_1 - X_2$ = " = $X_{12} - X_{13}$)		CALIBRATED* HORIZONTAL DISTANCE VALUES		HORIZONTAL TRANSLATIONAL ERROR ($\Delta E_X = \Delta X_C - \Delta X_1$ $\Delta E_Y = \Delta Y_C - \Delta Y_1$)	
	X_{1-13}	Y_7	ΔX_1	ΔY_1	ΔX_C	ΔY_C	ΔE_X	ΔE_Y
1					25.399	0.000		
2					8.257	0.000		
3					4.443	0.000		
4					3.810	0.000		
5					1.588	0.000		
6					0.954	0.000		
7					0.951	0.000		
8					1.588	0.000		
9					3.811	0.000		
10					4.445	0.000		
11					8.253	0.000		
12					25.401	0.000		
13								
(LEFT)								

* CALIBRATED VALUES SUPPLIED BY TARGET MANUFACTURER WITH UNITS IN MILLIMETERS.

NAME _____
DATE _____

INSTRUMENT _____

XXIX. ORTHOGONALITY TEST NO. 1 (Cont'd)

TRANSLATION DATA:

	VERTICAL MEASUREMENT DATA (STEPS 4 AND 5)		VERTICAL DISTANCE VALUES ($\Delta Y = Y_1 - Y_2$ = " = $Y_{12} - Y_{13}$)		CALIBRATED VERTICAL DISTANCE VALUES		VERTICAL TRANSLATIONAL ERROR ($\Delta E_X = \Delta X_C - \Delta X_1$ $\Delta E_Y = \Delta Y_C - \Delta Y_1$)	
	X_7	Y_{1-13}	ΔX_1	ΔY_1	ΔX_C	ΔY_C	ΔE_X	ΔE_Y
1					0.000	25.399		
2					0.000	8.256		
3					0.000	4.446		
4					0.000	3.808		
5					0.000	1.589		
6					0.000	0.952		
7					0.000	0.952		
8					0.000	1.588		
9					0.000	3.809		
10					0.000	4.448		
11					0.000	8.254		
12					0.000	25.400		
13								
(TOP)								
(BOTTOM)								

* CALIBRATED VALUES SUPPLIED BY TARGET MANUFACTURER WITH UNITS IN MILLIMETERS.

NAME _____
DATE _____

INSTRUMENT _____

XXXI. TENSION TEST NO. 1
COMMENTS AND TEST DATA:

NAME _____
DATE _____

INSTRUMENT _____

XXXII. SURFACE TEMPERATURE TEST NO. 1
COMMENTS AND TEST DATA:

SECTION V
GLOSSARY

SECTION V

GLOSSARY

ACCOMMODATION, EYE

A function of the human eye, whereby its total refracting power is varied in order to clearly see objects at different distances. When viewing through an optical instrument, this ability allows the eye to focus independently on portions of an image (within the field-of-view), which are not in focus in the same plane.

ACCURACY

The ability of a test to measure the true magnitude of a phenomenon in terms of the maximum expected difference between the measured value and the true value. It may be expressed as an absolute amount in the same units as the measured value or as a percentage of the true value. Associated with the accuracy of a single measurement is the repeatability of that measurement.

ACUITY ADJUSTMENT

Many binocular viewing instruments provide a range of relative focusing capability between the two optical trains. This is intended to allow for some disparities between the two eyes of the observer. Thus each eye can be provided with an image individually focused for its own best viewing. The mechanism which allows for such an adjustment is sometimes called an acuity adjustment. It may also be referred to as an eyepiece focusing adjustment. It is not to be confused, however, with a focusing or focusable eyepiece.

ALIGNMENT, OPTICAL

The condition of having all optical components in their proper positions relative to the optical axis. This is generally achieved by positioning all of the optical components with their individual optical axes coincident.

BINOCULAR INSTRUMENT

An instrument capable of providing two images or a single image to be viewed by both eyes of an observer simultaneously.

CUT-IN

A type of vignetting that is usually observed while rotating an optical component. It is due to the misalignment of a limiting aperture. It is readily noticeable to the unaided eye. (See VIGNETTING.)

DIOPTER

A unit of refractive power of a lens or prism. In a lens or lens system, it is numerically equal to the reciprocal of the focal length measured in meters.

DIOPTER TELESCOPE

An optical instrument which is designed to fit over the eyepiece of an optical viewing system. It essentially provides an additional amount of magnification for examining images produced by the viewing system. It includes a focusing type mechanism which enables the user to measure eyepiece focus adjustments in diopters.

DISTORTION, STEREO IMAGE

Distortion is nonuniform magnification within a field of view. Stereo image distortion is differential distortion between two optical trains in a stereoscopic or hyperstereoscopic viewing system. Thus, it is a difference in magnification between corresponding points in a pair of fields-of-view for stereoscopic viewing. Stereo image distortion produces a false sense of depth to the observer.

EMPTY MAGNIFICATION

A defect in viewing instruments having more than one possible magnification level. Ideally an instrument's resolving power increases linearly with increased magnification. In some instruments this is actually the case; in others the magnification increases faster than the resolving power. Empty magnification is the situation where the resolution does not increase at all with an increase in magnification over a certain range.

EXIT PUPIL

The image of the limiting aperture in an optical system, formed by all lenses following this aperture. In microscopes, the exit pupil is located above the eyepiece.

EYE RELIEF

The distance from the vertex of the last optical surface of the visual optical system to the exit pupil. Also called the eye distance.

EYEPIECE, COMPATIBLE

Any eyepiece which mechanically fits on an item of visual optical equipment and provides the same (if any) optical compensations as those eyepieces specifically designed for the equipment. (With other than production line models of optical equipment, the manufacturer or the instrument literature should be consulted before eyepieces other than those provided with the instrument are used.)

EYEPIECE, FOCUSING

An eyepiece with an internal focus adjustment for the eye lens to permit focusing on a reticle independent of focusing on the object or object image. Also called a focusable eyepiece. Not to be confused with an acuity adjustment or an eyepiece focus adjustment.

EYEPIECE, RETICLE

An image on a transparent substrate to be placed into an eyepiece so that the reticle image and the object image of the instrument can be viewed simultaneously in the same plane. The reticle serves as a constant image to which object images can be compared.

FIELD-OF-VIEW

The maximum cone of rays passed by all apertures in an optical system and measured in the object plane.

FOCUS, BEST

See Section II.

HYPERSTEREOSCOPIC

Having an enhanced three-dimensional appearance due to an abnormally large separation between the binocular points of view.

INSTRUMENT

In this manual, when underlined, refers to that piece of equipment which is to be tested and evaluated.

INTERPUPILLARY DISTANCE

The distance between the two eye pupils, when the observer is viewing distant objects. When referring to a binocular instrument, the eye pupils of the observer are placed at the two exit pupils of the instrument. Hence, the distance between the exit pupils of a binocular instrument is called the instrument's interpupillary distance.

MAGNIFICATION, EYEPIECE

Absolute magnification; numerically, the distance of distinct vision (25.0 cm) divided by the equivalent focal length of the lens (in cm.).

MAGNIFICATION, OBJECTIVE, RELAY, OR ZOOM

Lateral magnification, the ratio of the linear size of an image to the linear size of its object.

MICROSTEREOSCOPE

A stereoscopic viewing instrument having two separate optical trains, each being a compound microscope. It is designed specifically for the viewing of pairs of stereoscopic imagery. A high-power stereoscope.

NUMERICAL APERTURE (N.A.)

The product of the sine of the acceptance angle of a lens or lens system and the index of refraction of the medium between the lens and the object. $N.A. = N \sin \theta$

OBJECTIVE

The optical component which receives light from the object and forms the first or primary image in telescopes and microscopes.

OCULAR

The eyepiece of an optical instrument or the complete eyepiece assembly.

PARALLAX

The apparent displacement (or the difference in the apparent direction) of an object, as seen from two different points. Parallax between two objects thus indicates that they are not in the same plane.

PARCENTRATION

The ability of an optical instrument to keep an object centered in the field-of-view when optical components are varied or interchanged, such as changing objectives or changing zoom magnification, etc.

PARFOCALIZATION

The ability of an optical instrument to keep an object in focus when optical components are varied or interchanged, such as changing objectives or changing zoom magnification, etc.

PECHAN PRISM

An assembly consisting of a pair of prisms which together invert an optical image and pass the inverted image through in approximately the same direction as the original image. It thus has the useful property such that if it is rotated about the image axis, the image will rotate with the pechan prism in the same direction and at the same rate.

PHORIA

The orientation of the visual axes. When applied to a stereomicroscope, it is the orientation of the two optical axes. In their proper orientation, the axes cross at the point where they are in focus.

POINTER, INTERNAL OPTICAL

An arrow, point, circle, pair of cross lines, etc. which is optically projected into the field-of-view of an optical viewer. It may also be physically placed in an image plane. It can either be fixed or movable and is used to indicate particular places or objects within the field-of-view.

PRECISION

The degree of discrimination with which a quantity is described or stated, or the degree of exactness with which a quantity is stated. It is not to be considered the degree of correctness with which a quantity is stated. Precision is commonly denoted by the number of significant figures stated or implied in a quantity. For a measuring instrument, the precision is the smallest increment or division.

QUALITATIVE

Pertaining to or concerned with nonnumerical descriptors and measures.

QUANTITATIVE

Pertaining to or concerned with numerical descriptors and measures.

RELAY LENSES

Those lenses and lens systems which intervene between the objective and the eyepiece of a microscope or similar instrument. They may be used to simply displace or reorient the image produced by the objective, or to provide additional and sometimes variable magnification.

REPEATABILITY

The ability of a measurement or test to yield identical values of a phenomenon that is stable during the time interval in which the measurements or tests are performed.

RESOLUTION

A representative indicator of the ability to resolve or distinguish objects from one another.

RHOMBOID ARMS

An image relay component of an optical viewing system consisting basically of a rhomboid prism. An instrument objective is normally contained in or attached to one of these arms. The arm can be rotated, scanning a flat surface without a) changing the optical path length, b) moving the remainder of the optical components, or c) rotating the image. The scanned object thus remains in focus.

SAGITTAL RESOLUTION

That resolution involved in distinguishing between off-axis objects in a field-of-view that are located the same distance radially from the center of the field but are separated angularly. In a bar target, the sagittal bars are roughly parallel to a field-of-view radius passing through them.

SEPARATION, OPTICAL PATH

The X and Y distances between the centers of the object fields of view of the two optical trains in a microstereoscope. The X - and Y -directions are referred to the instrument, with X the direction between the left and right eyepieces, and Y the direction perpendicular to X and parallel to the stage.

SINGLE OPTICAL TRAIN

Those optical components through which the image for a single eye passes. In stereoscopic instruments, two optical trains are necessary, although it is possible to share certain optical components by using different areas.

STAGE MICROMETER

A calibrated scale of small dimensions for use with a microscope to measure microscopic objects or for the calibration of microscope reticles. It is placed on the microscope stage and its image is compared to the reticle or the image of the object to be measured or calibrated.

STEREOMICROSCOPE

A binocular microscope providing each eye with a separate view of the same physical object. The two views differ from one another in perspective. When a three-dimensional object is viewed, the observer can perceive its three-dimensional nature through such an instrument.

TANGENTIAL RESOLUTION

That resolution involved in distinguishing between off-axis objects in a field-of-view that are located in the same radial direction from the center of the field but are separated in distance from the center along that radius. In a bar target, the tangential bars are roughly perpendicular to the field-of-view radius passing through them.

VIGNETTING

The obscuration of oblique rays by apertures in an optical system causing a marked reduction in the oblique illuminance. Decentering of limiting apertures can cause a form of vignetting sometimes called cut-in where the decentered aperture causes an even more pronounced reduction in the illumination in an area of the field-of-view.

WORKING DISTANCE

The clear distance between the lowest element of an optical system or its mechanical holder and the object plane of the instrument.

ZOOM LENS

A lens which is moved with relation to the object in order to change the magnification. More commonly used and also referred to as simply a zoom lens or system is the "mechanically compensated" zoom lens. This compound lens, actuated by a single control, contains elements which move relative to one another by means of cams. The movement is such that the object and its image remain fixed in position, while the size of the image is varied. Optically compensated zoom lenses, a third category, do not remain continuously in focus throughout the magnification range but are compensated at a number of discrete positions.

BIBLIOGRAPHY

1. Modern Optical Engineering, Warren J. Smith, McGraw-Hill Book Co., New York 1966.
2. Military Standard Optical Terms and Definitions MIL-STD-1241A, March 31, 1967
3. Encyclopedic Dictionary of Physics, The MacMillan Company, New York, 1962 J. Thewlis Editor-in-Chief.
4. Webster's New International Dictionary, Third Edition Unabridged. G. C. Merriam Company, Springfield, Mass.
5. Martin H. Weik, Standard Dictionary of Computers and Information Processing, Hayden Book Company, Inc., New York 1969.
6. Rudolf Kingslake, Applied Optics and Optical Engineering, Academic Press, New York 1965.

NOTE

This bibliography applies only to the Glossary and not the balance of the manual.

SECTION VI

INDEX

SECTION VI

INDEX

Accommodation, eye	II-3, III-2-4, III-2-7, V-1
Acuity adjustment	III-1-6, III-1-8, III-1-10, V-1
Alignment, optical	V-1
image decentration	III-5-1
phoria	III-5-5, V-5
vignetting	III-5-7, III-5-8, V-8
zoom image shift or jump	III-5-3
Bar targets	II-4
Best focus	II-4
Binocular instruments, general	II-3, V-2
Cut-in	III-5-7, III-5-8, V-2
Decentration, image	III-5-1
Diopter telescope	III-1-1, III-1-4, III-1-6, III-1-8, III-1-10 III-1-13, III-2-1, III-2-2, V-2 II-3, III-2-4, III-2-7
instructions for use	III-3-1, III-3-3, V-2
Distortion, stereo image	III-2-2, V-2
Empty magnification	III-13-1, V-3
Exit pupil	III-1-2, III-1-13
Extension arms, rotation of	
Eye	
accommodation	II-3, III-2-4, V-1
relief	III-13-1, III-14-1, V-3
Eyeiece	
focus adjustment	see Acuity adjustment
focusing (focusable)	V-3
magnification	III-7-1
Field-of-view	III-9-1, V-3
Focus (also see Parfocalization)	
best	II-4
changes due to component rotation	III-1-13
relative	III-1-6
Focusing eyepiece	V-3
Image decentration	III-4-1
	VI-1

Interpupillary distance III-13-1, V-4
 Lenses, relay II-3, V-6
 Magnification
 empty III-2-2, V-2
 eyepiece III-7-1, V-4
 objective, relay and zoom III-7-1, V-4
 Numerical aperture III-8-1, V-4
 Off-axis resolution III-2-4, III-2-6, III-2-7
 Optical path separation III-16-1, V-7
 Parallax III-6-1, V-5
 Parcentration V-5
 between left and right optical
 trains (phoria) III-5-5
 rotatable components III-5-1
 zoom system III-5-3
 Parfocalization V-5
 between left and right optical trains III-1-6
 without zoom system III-1-1
 zoom system III-1-4
 Pechan prism V-5
 image rotation III-5-1
 Phoria III-5-5, V-5
 Pointer, internal optical III-6-1, V-6
 Reading bar targets II-4
 Relay lenses II-3, V-5
 Replication of tests II-2, II-6, II-7
 Resolution V-6
 off-axis III-2-4, III-2-6, III-2-7
 on-axis III-2-1
 sagittal II-5, III-2-4, III-2-7, V-7
 tangential II-5, III-2-4, III-2-7, V-8
 targets II-4, II-5
 versus magnification III-2-2
 Resolving power see Resolution
 Rhomboid arm V-7
 rotation III-1-2, III-1-13

Rotation
 of targets II-5
 of optical components III-1-2, III-1-13, III-5-1, III-5-7
 Sagittal resolution II-5, III-2-4, III-2-7, V-7
 Selectable discrete relay magnifications II-3, V-6
 Separation, optical path III-16-1, V-7
 Stereo image distortion III-3-1, V-2
 Suitable target II-4
 Tangential resolution II-5, III-2-4, III-2-7, V-8
 Target
 care of II-5
 choice of II-4
 reading resolution II-4
 suitable II-4
 use of II-5
 Test program II-1
 Vignetting III-5-7, III-5-8, V-8
 Working distance III-11-1, V-8
 Zoom lens V-8
 general comments II-3
 image shift and jump III-5-3
 parcentration III-5-3
 parfocalization III-1-4